# Appendix 9.5

# BART Analysis for KCP&L - La Cygne Units 1 and 2

# CALPUFF BART MODELING PROTOCOL ▪ KANSAS CITY POWER & LIGHT

LA CYGNE GENERATING STATION

**VERSION 0**

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# Table of Contents

# LIST OF TABLES

# LIST OF FIGURES

## 1.1 BACKGROUND

On July 1, 1999, the U.S. Environmental Protection Agency (EPA) published the final Regional Haze Rule (RHR). The objective of the RHR is to improve visibility in 156 specific areas across with United States, known as Class I areas. The Clean Air Act defines Class I areas as certain national parks (over 6000 acres), wilderness areas (over 5000 acres), national memorial parks (over 5000 acres), and international parks that were in existence on August 7, 1977.

On July 6, 2005, the EPA published amendments to its 1999 RHR, often called the Best Available Retrofit Technology (BART) rule, which included guidance for making source-specific BART determinations. The BART rule defines BART-eligible sources as sources that meet the following criteria:

(1) Have potential emissions of at least 250 tons per year of a visibility-impairing pollutant,
(2) Began operation between August 7, 1962 and August 7, 1977, and
(3) Are listed as one of the 26 listed source categories in the guidance.

A BART-eligible source is not automatically subject to BART. Rather, BART-eligible sources are subject-to-BART if the sources are "reasonably anticipated to cause or contribute to visibility impairment in any federal mandatory Class I area." EPA has determined that sources are reasonably anticipated to cause or contribute to visibility impairment if the visibility impacts from a source are greater than 0.5 deciviews (dv) when compared against a natural background.

Air quality modeling is the tool that is used to determine a source's visibility impacts. States have the authority to exempt certain BART-eligible sources from installing BART controls if the results of the modeling demonstrate that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. Further, states also have the authority to define the modeling procedures for conducting modeling related to making BART determinations.

## 1.2 LOCATION OF SOURCES AND RELEVANT CLASS I AREAS

Kansas City Power & Light (KCP&L) has identified the following sources that meet the three criteria for being BART-eligible sources:

- ▲ La Cygne Generating Station – Boiler Unit 1
- ▲ La Cygne Generating Station – Boiler Unit 2

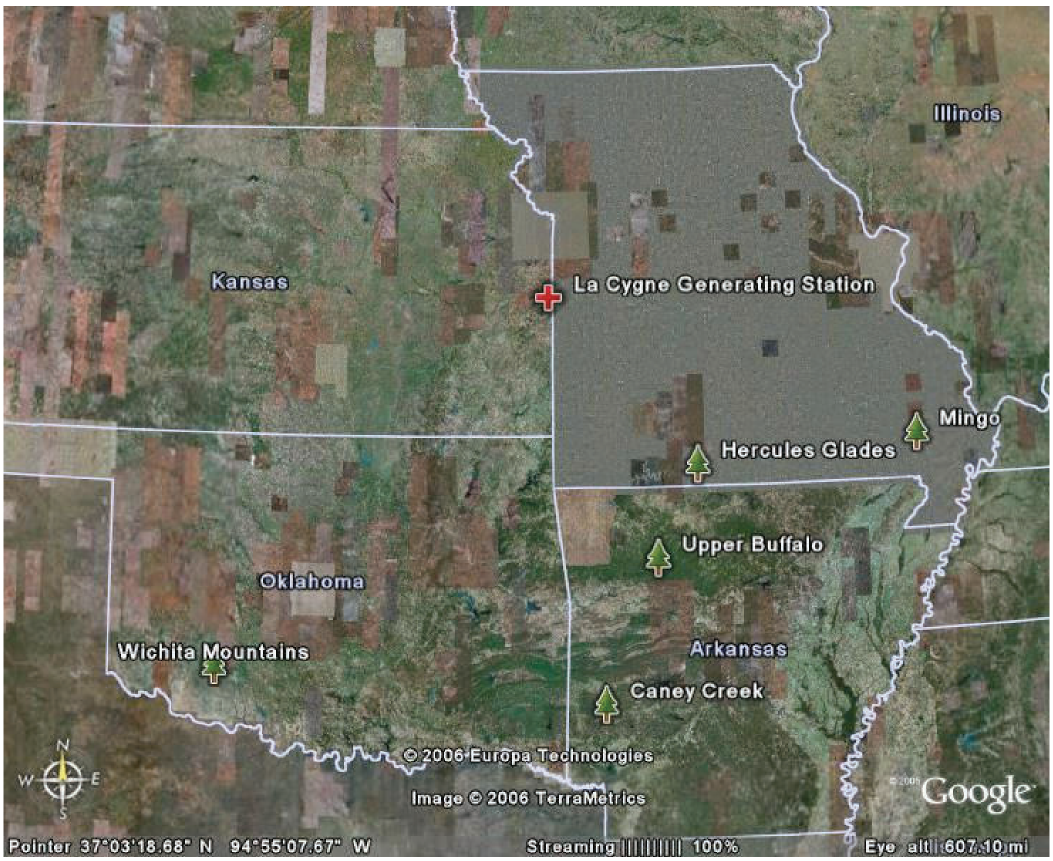
Table 1-1 provides a summary of the distances from the La Cygne Generating Station to nearby Class I areas.

**TABLE 1-1. DISTANCE TO CLASS I AREAS**

| Source | Distance to Class I Area (km) | | | | |
|---|---|---|---|---|---|
| | Wichita Mountains | Hercules-Glades | Upper Buffalo | Caney Creek | Mingo |
| La Cygne | 533.4 | 233.6 | 291.5 | 437.8 | 416.4 |

Figure 1-1 provides a plot of the location of the La Cygne Generating Station with respect to the listed Class I areas.

**FIGURE 1-1. LOCATION OF KCP&L LA CYGNE GENERATING STATION AND NEARBY CLASS I AREAS**




## 1.3 OBJECTIVE

The objective of this document is to provide a protocol summarizing the modeling methods and procedures that KCP&L will follow as we evaluate the visibility impacts attributable to La Cygne Unit 1 and La Cygne Unit 2 in the Class I areas listed in Table 1-1. Initially, KCP&L will use the methods in this protocol to determine the visibility impacts based on the existing emission rates and exhaust characteristics for the units (See Section 4). We will also use the methods in this protocol to evaluate BART control options. Since we are in the process of evaluating control options, no specific emission rates or exhaust characteristics based on BART control options are provided in this protocol.

# 2. CALPUFF MODEL SYSTEM

The main components of the CALPUFF modeling system are CALMET, CALPUFF, and CALPOST. CALMET is the meteorological model that generates hourly three-dimensional meteorological fields such as wind and temperature. CALPUFF simulates the non-steady state transport, dispersion, and chemical transformation of air pollutants emitted from a source in "puffs". CALPUFF calculates hourly concentrations of visibility affecting pollutants at each specified receptor in a modeling domain. CALPOST is the post-processor for CALPUFF, and CALPOST computes visibility impacts from a source based on the visibility affecting pollutant concentrations that were produced by CALPUFF.

## 2.1 MODEL VERSIONS

Earth Tech, Inc. is the primary developer of the CALPUFF modeling system and all related programs. The versions of the CALPUFF modeling system programs that will be used to model La Cygne Unit 1 and Unit 2 are listed in Table 2-1. Table 2-1 also compares the program versions that will be used to model La Cygne Unit 1 and Unit 2 with the program versions recommended by CENRAP. Note that some of the program versions are not the same as the program versions recommended by CENRAP. The program versions are different due to the fact that several of the program versions recommended by CENRAP are incompatible with each other as published. Specifically, the MM5 data extraction program (CALMM5) Version 2.4 is not compatible with CALMET Version 5.53a. CALMM5 Version 2.4 is compatible with a newer version of CALMET, Version 5.551. Note that meteorological data that is generated with CALMET Version 5.551 is not compatible with CALPUFF Version 5.711a. CALMET Version 5.551 is compatible with CALPUFF Version 5.727. In short, alternate program versions are required in order to accommodate the MM5 data extraction program version, so KCP&L will use alternate versions.

**TABLE 2-1. CALPUFF MODELING SYSTEM VERSIONS**

| Program | CENRAP Suggested | | KCP&L Analyses | | Reason for Difference |
|---|---|---|---|---|---|
| | Version | Level | Version | Level | |
| TERREL | 3.311 | 030709 | 3.311 | 030709 | |
| CTGCOMP | 2.42 | 030709 | 2.22 | 030528 | Version recommended is not available |
| CTGPROC | 2.42 | 030709 | 2.42 | 030709 | |
| MAKEGEO | 2.22 | 030709 | 2.22 | 030709 | |
| CALMM5 | 2.4 | 050413 | 2.4 | 050413 | Modified code used by Alpine Geophysics |
| CALMET | 5.53a | 040716 | 6.211 | 060414 | Needed to process multiple CALMM5 files |
| CALPUFF | 5.711a | 040716 | 6.112 | 060412 | Needed to process CALMET output |
| POSTUTIL | 5.51 | 030709 | 6.131 | 060410 | Needed to process CALPUFF output |
| CALPOST | 3.311 | 030709 | 3.311 | 030709 | |

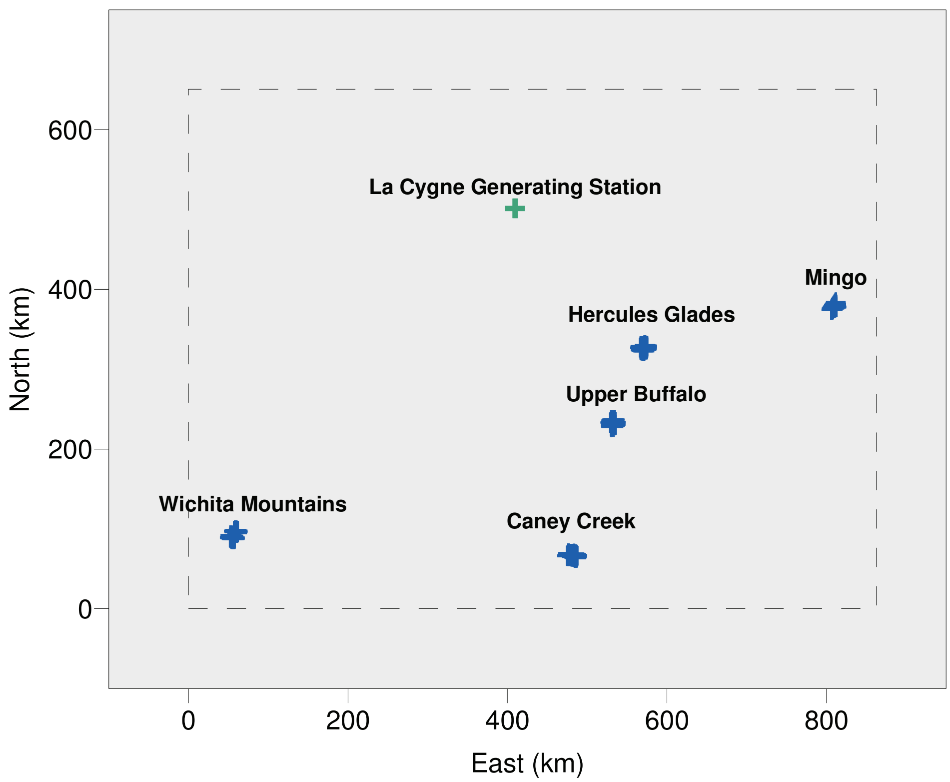
## 2.2 MODELING DOMAIN

The modeling domain for the La Cygne Generating Station is the same domain that has been calculated for other BART-eligible electric generating units in Kansas. The domain extends at least 50 km in all directions beyond the La Cygne Generating Station and the five Class I areas of interest. The map projection for the modeling domain is Lambert Conformal Conic (LCC) and the coordinate system is World Geodetic System 1984 (WGS84), which is an LCC projection. The meteorological grid spacing is 2.5 km.

The southwest corner of the modeling domain is Latitude 33.92ºN, Longitude 99.35ºW which will be assigned as the 0, 0 reference point for the domain. The northeast corner of the modeling domain is approximately Latitude 39.77ºN, Longitude 89.29ºW. At a grid spacing of 2.5 km, the number of X grid cells will be 346 and the number of Y grid cells will be 261.

Figure 2-1 provides a plot of the modeling domain with respect to the sources and Class I areas.

**FIGURE 2-1. PROPOSED MODELING DOMAIN**



# 3. CALMET

KCP&L will conduct a three-year CALMET analysis that incorporates both mesoscale model and observation meteorological data. The CALMET analysis will generate three years of data that will be input to CALPUFF. The CALMET model requires the input of geophysical data, meteorological data, and model parameter settings. The CALMET modeling procedures that will be used will generally follow the recommendations in CENRAP's protocol. However, some of CENRAP's recommendations only apply to CALMET analyses that incorporate mesoscale model meteorological data (and no observation data). Since the CALMET analysis for KCP&L's modeling will be a hybrid analysis (mesoscale model data plus observation data), it is expected that some parameters will be different.

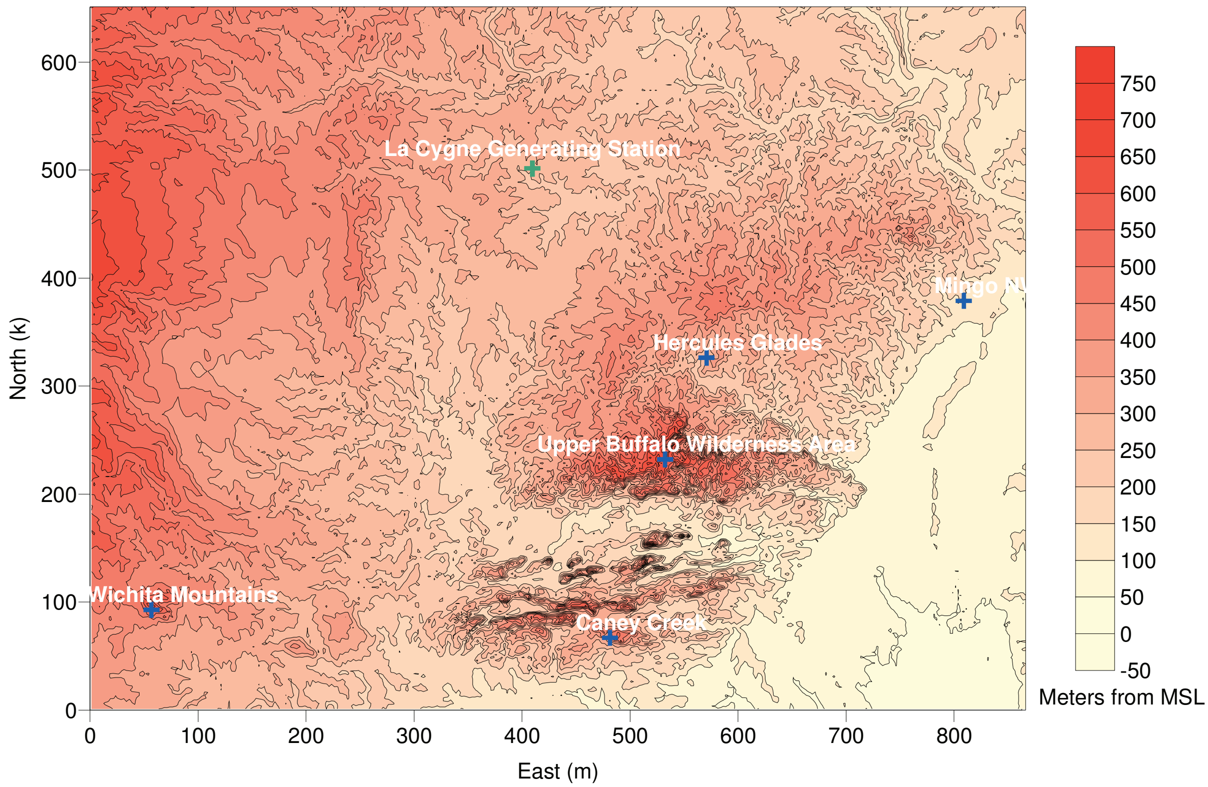
## 3.1 GEOPHYSICAL DATA

CALMET requires geophysical data to characterize the terrain and land use parameters that potentially affect dispersion. Terrain features affect flows and create turbulence in the atmosphere and are potentially subjected to higher concentrations of elevated puffs. Different land uses exhibit variable characteristics such as surface roughness, albedo, Bowen ratio, and leaf-area index that also effect turbulence and dispersion.

### 3.1.1 TERRAIN DATA

Terrain data from the United States Geological Survey (USGS) in 1-degree (1:250,000 scale or approximately 90 meter resolution) digital format will be used. A list of the USGS terrain files is provided in Appendix A. A plot of the land elevation for the modeling domain based on the referenced files is provided in Figure 3-1.

**FIGURE 3-1. PLOT OF LAND ELEVATION USING USGS TERRAIN DATA**

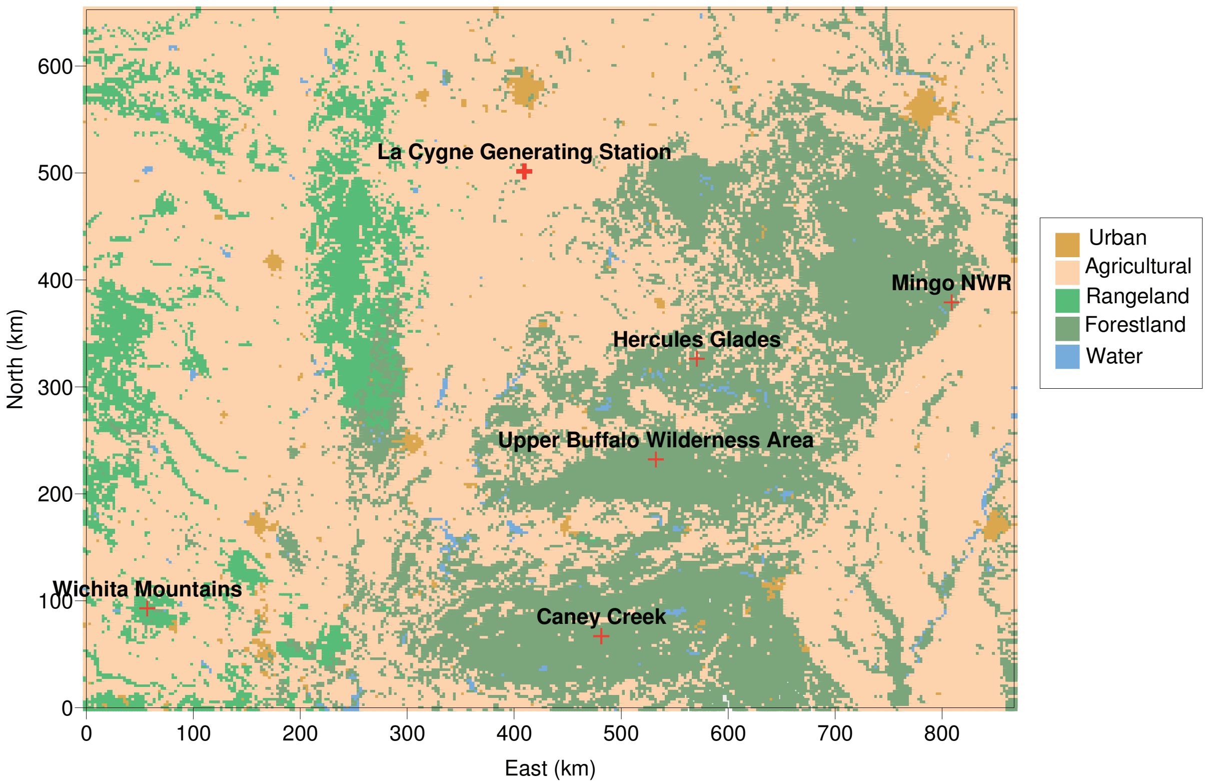



The USGS terrain data will be input into the TERREL program to generate grid-cell elevation averages across the modeling domain.

### 3.1.2 LAND USE DATA

USGS Composite Theme Grid (CTG) format Land Use and Land Cover (LULC) data files at 1:250,000 resolution will be used, where available. Where 1:250,000 land use data is not available, USGS data at 1:100,000 resolution will be used. A list of the USGS land use files is provided in Appendix A. A plot of the land use for the modeling domain based on the referenced files is provided in Figure 3-2.

**FIGURE 3-2. PLOT OF LAND USE USING USGS LULC DATA**




The LULC data will be input into the CTGPROC program to generate land use for each grid cell across the modeling domain. The USGS CTG format LULC data files must be compressed prior to use in the CTGPROC utility processor; therefore the files will be compressed using the program CTGCOMP.

### 3.1.3 COMPILING TERRAIN AND LAND USE DATA

The terrain data files output by the TERELL program and the LULC files output by CTGPROC program will be input to the program MAKEGEO to create a geophysical data file that will be input to CALMET.

## 3.2 METEOROLOGICAL DATA

CALMET will be used to assimilate data for 2001, 2002, and 2003 using mesoscale model output and National Weather Service (NWS) surface station observations and precipitation station observations to develop the meteorological field.

### 3.2.1 MESOSCALE MODEL METEOROLOGICAL DATA

Hourly mesoscale data will be used to supplement the hourly surface, upper air, and precipitation observation data. The mesoscale data will be used to define the initial guess field for the CALMET simulations. The following 5th generation mesoscale model (MM5) meteorological data sets will be used:

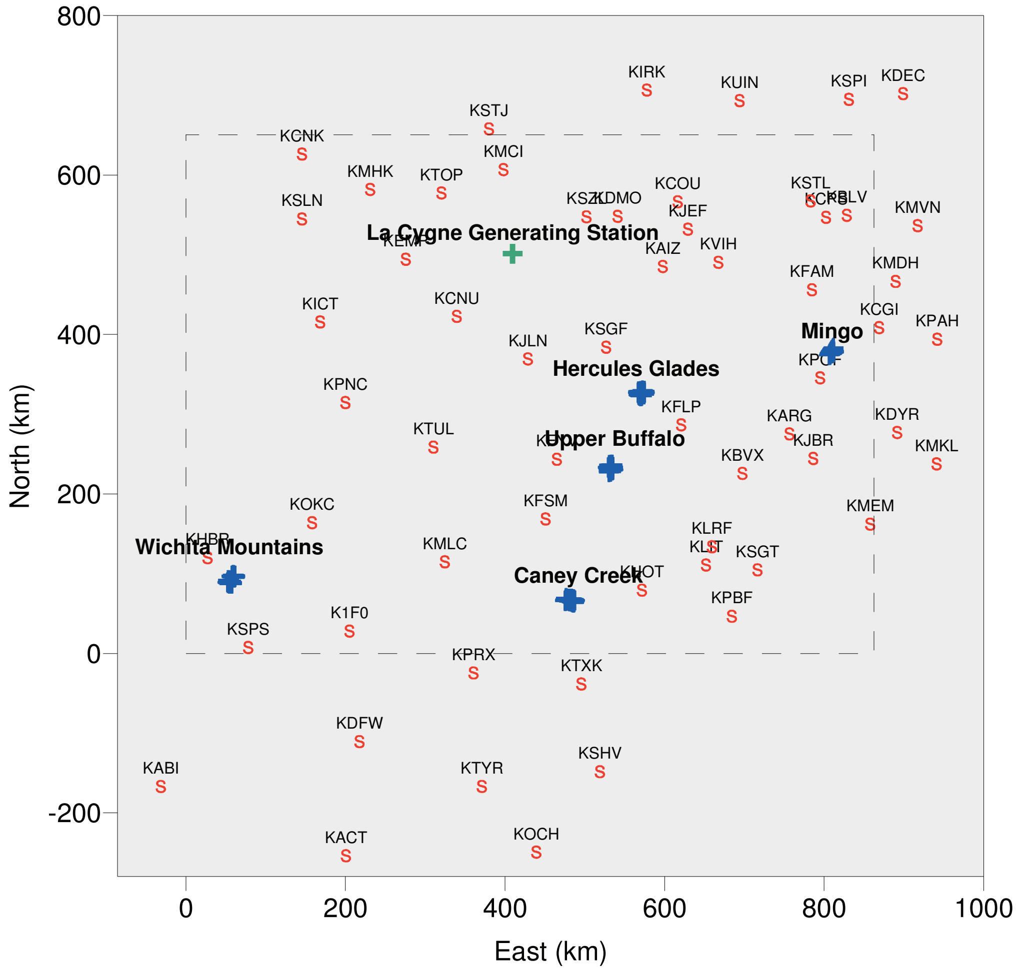
- 2001 MM5 data at 12 km resolution processed for EPA by Alpine Geophysics
- 2002 MM5 data at 36 km resolution processed by Iowa DNR
- 2003 MM5 data at 36 km resolution processed by the Midwest RPO

The MM5 data for the CENRAP region was extracted from the above MM5 data sets by Alpine Geophysics using the CALMM5 program. Trinity will use this extracted MM5 data.

### 3.2.2 SURFACE METEOROLOGICAL DATA

Parameters affecting turbulent dispersion that are observed hourly at surface stations include wind speed and direction, temperature, cloud cover and ceiling, relative humidity, and precipitation type. The surface stations from which data will be extracted are listed in Appendix B. The locations of the surface stations with respect to the modeling domain are shown in Figure 3-3. These stations were selected from the available data inventory to optimize spatial coverage and representation of the domain. Data from the stations will be processed for use in CALMET using Version 5.55, Level: 050311 of EPA's SMERGE program.

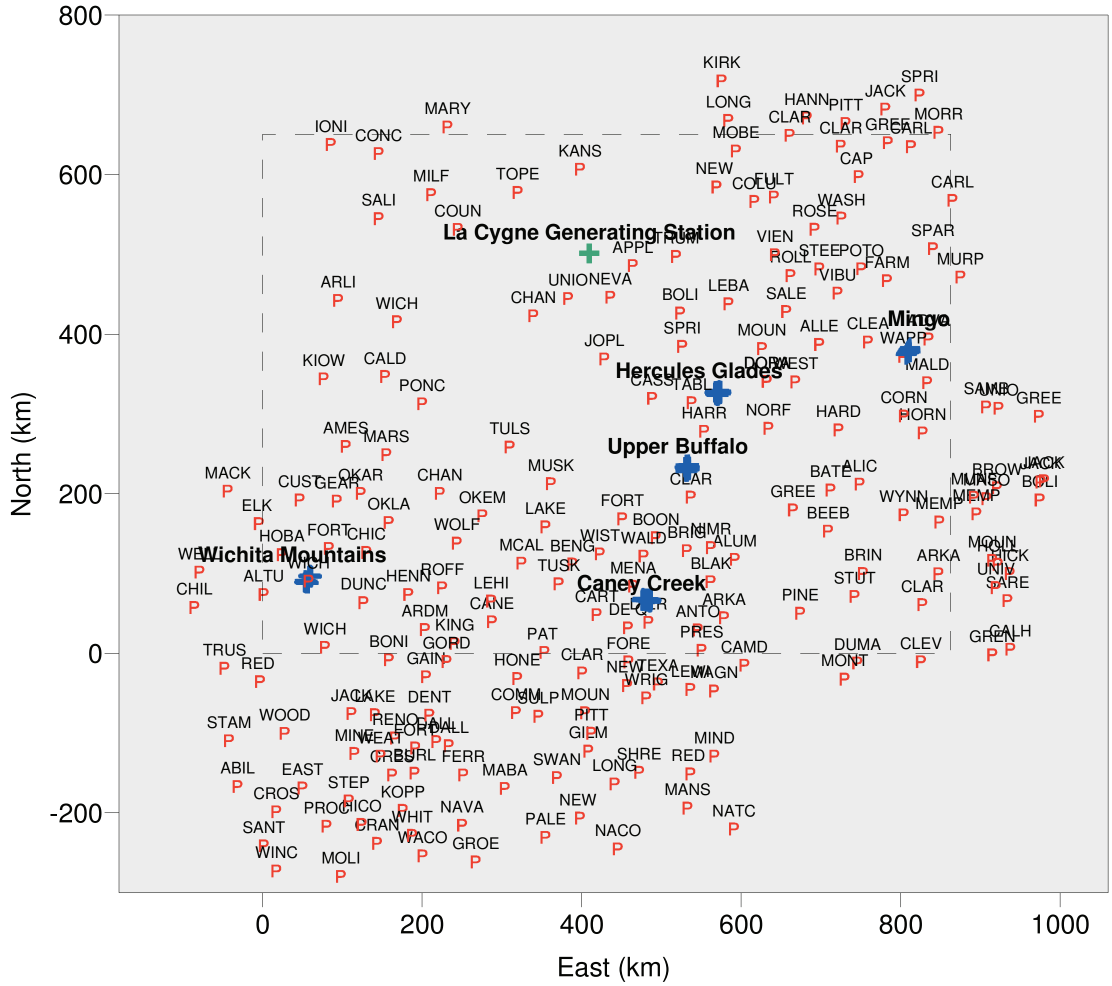
**FIGURE 3-3. PLOT OF SURFACE STATIONS**




### 3.2.3 PRECIPITATION METEOROLOGICAL DATA

The effects of chemical transformations and deposition processes on ambient pollutant concentrations will be considered in this analysis. Therefore, it is necessary to include observations of precipitation in the CALMET analysis. The precipitation stations from which data will be extracted are listed in Appendix B. The locations of the precipitation stations with respect to the modeling domain are shown in Figure 3-4. These stations were selected from the available data inventory to optimize spatial coverage and representation of the domain. Data from the stations will be processed for use in CALMET using Version 5.31, Level: 030528 of EPA's PMERGE program.

**FIGURE 3-4. PLOT OF PRECIPITATION METOROLOGICAL STATIONS**




## 3.3 SUMMARY OF CALMET CONTROL PARAMETERS

Table 3-1 provides a listing of the CALMET parameters will be used in the modeling analysis. In addition to the parameters that will be used for the modeling, the table also lists CENRAP's recommended parameters for comparison. In cases where a parameter to be used is different than what CENRAP recommended, a short explanation as to the difference is proved. Note that most of the differences from CENRAP's recommended parameters are due to the inclusion of observation data into the modeling analysis, since CENRAP's parameters are based on a no-observation analysis.

**TABLE 3-1. SUMMARY OF CALMET INPUTS**

| CALMET Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| NUSTA | Number of upper air data sites | 0 | 0 | Will not use observations |
| NOWSTA | Number of overwater data sites | 0 | 0 | |
| IBYR | Starting year | 2001 | Appropriate met year | Years 2001, 2002, 2003 |
| IBMO | Starting month | 1 | Appropriate month | Due to file size, analysis will be completed by month |
| IBHR | Starting hour | 1 | 1 | |
| IBTZ | Base time zone | 6 | 6 | |
| IRLG | Length of run | 6 | Varies with month | Due to file size, analysis will be completed by month |
| IRTYPE | Run type (1 for CALPUFF) | 1 | 1 | |
| LCALGRD | Compute CALFRID data fields (T = run CALGRID) | F | F | |
| ITEST | Stop run after SETUP to do input QA (2 = run) | 2 | 2 | |
| PMAP | Map projection | LCC | LCC | |
| RLAT0 | Latitude (decimal degrees) of projection origin | 40N | 33.9195N | Appropriate for domain |
| RLON0 | Longitude (decimal degrees) of projection origin | 97W | 99.3480W | Appropriate for domain |
| XLAT1 | Latitude of 1st standard parallel | 33N | 33N | Appropriate for domain |
| XLAT2 | Latitude of 2nd standard parallel | 45N | 40N | Appropriate for domain |
| DATUM | Datum region for output coordinates | WGS-G | WGS-G | Selected datum to match datum of land use data |
| NX | Number of X grid cells in meteorological grid | 300 | 346 | Appropriate for domain |
| NY | Number of Y grid cells in meteorological grid | 192 | 261 | Appropriate for domain |
| DGRIDKM | Grid spacing (km) | 6.0 | 2.5 | Refined grid spacing |
| XORIGKM | Ref. coordinate of SW corner of grid cell | -1008 | 0 | Appropriate for domain |
| YORIGKM | Ref. coordinate of SW corner of grid cell | 0.0 | 0 | Appropriate for domain |
| NZ | Number of vertical layers | 10 | 10 | |
| ZFACE | Vertical cell face heights (NZ + 1 values) | 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000 | 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000 | |

| CALMET Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| LSAVE | Save met. data fields in an unformatted file? | T | T | |
| IFORMO | Type of unformatted output file (1 for CALPUFF) | 1 | 1 | |
| LPRINT | Print met. fields | F | F | |
| IPRINF | Print intervals | 1 | 1 | |
| IUVOUT(NZ) | Specify layers of u,v wind components to print | NZ*0 | NZ*0 | |
| IWOUT(NZ) | Specify layers of w wind component to print | NZ*0 | NZ*0 | |
| ITOUT(NZ) | Specify layers of 3D temperature field to print | NZ*0 | NZ*0 | |
| LDB | Print met data and variables | F | F | |
| NN1 | First time step for debug data to be printed | 1 | 1 | |
| NN2 | Last time step for debug data to be printed | 1 | 2 | Will generate debug data for a total of 2 time steps |
| IOUTD | Control variable for writing test/debug wind fields | 0 | 0 | |
| NZPRN2 | Number of levels starting at surface to print | 0 | 1 | Default |
| IPRO | Print interpolated wind components | 0 | 0 | |
| IPR1 | Print terrain adjusted surface wind components | 0 | 0 | |
| IPR2 | Print initial divergence fields | 0 | 0 | |
| IPR3 | Print final wind speed and direction | 0 | 0 | |
| IPR4 | Print final divergence fields | 0 | 0 | |
| IPR5 | Print winds after kinematic effects | 0 | 0 | |
| IPR6 | Print winds after Froude number adjustment | 0 | 0 | |
| IPR7 | Print winds after slope flows are added | 0 | 0 | |
| IPR8 | Print final wind field components | 0 | 0 | |
| NOOBS | No observation mode (2 = No surface, overwater, or upper air observations; use MM5 for surface, overwater, and upper air data) | 2 | 1 | Will use surface observations only |
| NSSTA | Number of meteorological stations in SURF.DAT file | 0 | 45 | Number of stations |

| CALMET Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| NPSTA | Number of precipitation stations in PRECIP.DAT file | 0 | 206 | Number of stations |
| ICLOUD | Gridded cloud fields (0 = no, 3 = Gridded cloud cover from prognostic relative humidity) | 3 | 0 | |
| IFORMS | Format of surface data (2 = formatted) | 2 | 2 | |
| IFORMP | Format of precipitation data (2 = formatted) | 2 | 2 | |
| IFORMC | Format of cloud data (2 = formatted) | 2 | 1 | N/A - No cloud data used in model |
| IWFCOD | Generate winds by diagnostic wind module? (1 = yes) | 1 | 1 | |
| IFRADJ | Adjust winds using Froude number effects? (1 = yes) | 1 | 1 | |
| IKINE | Adjust winds using kinematic effects? (0 = no) | 0 | 1 | Will compute kinematic effects in this analysis |
| IOBR | Use O'Brien procedure for vertical winds? (0 = no) | 0 | 0 | |
| ISLOPE | Compute slope flows? (1 = yes) | 1 | 1 | |
| IEXTRP | Extrapolate surface winds to upper layers (-1 = no extrapolation and ignore layer 1 of upper air station data) | -1 | -4 | -4 = Since observations are included in model, will use similarity theory and ignore layer 1 of upper air station data (FLAG default) |
| ICALM | Extrapolate surface winds even if calm? (0 = no) | 0 | 0 | |
| BIAS | Layer dependent biases weighting aloft measurements | 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 | 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 | |
| RMIN2 | Minimum vertical extrapolation distance<br><br>Distance (km) around an upper air site where vertical extrapolation is excluded (set to –1 if IEXTRP = ± 4) | -1 | -1 | |
| IPROG | Using prognostic or MM-FDDA data? (14 = Use winds from MM5.DAT as initial guess wind field) | 14 | 14 | |
| ISTEPPG | Timestep (hours) of the MM5 data | 1 | 1 | |

| CALMET Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| LVARY | Use varying radius of influence to develop surface winds? | T | F | Use FLAG default |
| RMAX1 | Maximum radius of influence over land in surface layer (km) | 30 | 100 | |
| RMAX2 | Maximum radius of influence over land aloft (km) | 30 | 500 | |
| RMAX3 | Maximum radius of influence over water (km) | 50 | 100 | |
| RMIN | Minimum radius of influence used anywhere (km) | 0.1 | 0.1 | |
| TERRAD | Radius of influence of terrain features (km) | 12 | 12 | |
| R1 | Weighting of first guess surface field (km) | 1 | 80 | |
| R2 | Weighting of first guess aloft field (km) | 1 | 200 | |
| RPROG | MM5 windfield weighting parameter (km) | 0 | 0 | |
| DIVLIM | Maximum acceptable divergence | 5.E-6 | 5.E-6 | |
| NITER | Max number of passes in divergence minimization | 50 | 50 | |
| NSMTH | Number of passes through smoothing filter in each layer of CALMET (NZ values) | 2, 4, 4, 4, 4, 4, 4 | 2, 4, 4, 4, 4, 4, 4, 4, 4, 4 | |
| NITR2 | Max number of stations used in each layer for the interpolation of data to a grid point (NZ values) | 5, 5, 5, 5, 5, 5, 5, 5, 5, 5 | 5, 5, 5, 5, 5, 5, 5, 5, 5, 5 | |
| CRITFM | Critical Froude number | 1.0 | 1.0 | |
| ALPHA | Kinematic effects parameter | 0.1 | 0.1 | |
| FEXTR2 | Scaling factor for extrapolating surface winds aloft | NZ*0.0 | NZ*0.0 | |
| NBAR | Number of terrain barriers | 0 | 0 | |
| IDIOTP1 | Compute temperature from observations (0 = true) | 0 | 0 | |
| ISURFT | Surface station to use for surface temperature (between 1 and NSSTA) | 4 | 4 | |
| IDIOPT2 | Domain-averaged wind component switch | 0 | 0 | |

| CALMET Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| IUPT | Station for lapse rates (between 1 and NUSTA) | 2 | 2 | |
| ZUPT | Depth through which lapse rate is calculated | 200 | 200 | |
| IDIOPT3 | Domain averaged wind component switch | 0 | 0 | |
| IUPWND | Upper air station for domain winds | -1 | -1 | |
| ZUPWND | Bottom and top of layer through which the domain scale winds are computed | 1., 1000. | 1., 1000. | |
| IDIOPT4 | Observed surface wind component switch | 0 | 0 | |
| IDIOPT5 | Observed aloft wind component switch | 0 | 0 | |
| LLBREZE | Use lake breeze module? | F | F | |
| NBOX | Number of lake breeze regions | 0 | 0 | |
| NLB | Number of stations in the region | 0 | 0 | |
| METBXID(NLB) | Station IDs in the region | 0 | 0 | |
| CONSTB | Neutral stability mixing height coefficient | 1.41 | 1.41 | |
| CONSTE | Convective stability mixing height coefficient | 0.15 | 0.15 | |
| CONSTN | Stable stability mixing height coefficient | 2400 | 2400 | |
| CONSTW | Overwater mixing height coefficient | 0.16 | 0.16 | |
| FCORIOL | Absolute value of Coriolis parameter | 1.E-4 | 1.E-4 | |
| IAVEZI | Conduct spatial averaging? (1 = yes) | 1 | 1 | |
| MNMDAV | Max search radius in averaging process (number of grid cells) | 10 | 10 | |
| HAFANG | Half-angle of upwind looking cone for averaging (degrees) | 30 | 30 | |
| ILEVZI | Layers of wind use in upwind averaging (between 1 and NZ) | 1 | 1 | |
| DPTMIN | Minimum potential temperature lapse rate in the stable layer above the current convective mixing height | 0.001 | 0.001 | |

| CALMET Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| DZZI | Depth of layer above current convective mixing height through which lapse rate is computed (m) | 200 | 200 | |
| ZIMIN | Minimum overland mixing height (m) | 50 | 50 | |
| ZIMAX | Maximum overland mixing height (m) | 3000 | 3000 | |
| ZIMINW | Minimum overwater mixing height (m) | 50 | 50 | |
| ZIMAXW | Maximum overwater missing height (m) | 3000 | 3000 | |
| ITPROG | 3D temperature from observations or from MM5? | 2 | 1 | Will use surface observations |
| IRAD | Type of interpolation (1 = 1/r) | 1 | 1 | |
| TRADKM | Temperature interpolation radius of influence (km) | 36 | 36 | |
| NUMTS | Max number of stations for temperature interpolations | 5 | 5 | |
| IAVET | Spatially average temperature? (1 = yes) | 1 | 1 | |
| TGDEFB | Temperature gradient below the mixing height over water (K/m) | -.0098 | -0.0098 | |
| TGDEFA | Temperature gradient above the mixing height over water (K/m) | -.0045 | -0.0045 | |
| JWAT1 | Beginning land use categories over water | 55 | 55 | |
| JWAT2 | Ending land use categories for water | 55 | 55 | |
| NFLAGP | Precipitation interpolation flag ($2 = 1/r^2$) | 2 | 2 | |
| SIGMAP | Radius of influence for precipitation interpolation (km) | 50 | 50 | |
| CUTP | Minimum precipitation rate cut off (mm/hr) | 0.01 | 0.01 | |

# 4. CALPUFF

KCP&L will conduct a three-year CALPUFF analysis. The CALPUFF model requires the input of meteorological data output by CALMET, source emissions data, receptor data, ozone and ammonia data, and model parameter settings.

## 4.1 SOURCE EMISSIONS DATA

The BART rule indicates that if the PTE is greater than 250 tpy for any visibility-impairing pollutant, a source is required to include emissions of all visibility impairing pollutants in the BART analysis. La Cygne Unit 1 and Unit 2 emit three primary visibility-impairing pollutants: $SO_2$, $PM_{10}$, and $NO_X$. Since the PTE for at least one of these pollutants is above 250 tpy, KCP&L will include emissions of all three pollutants in the BART modeling analysis.

### 4.1.1 $SO_2$, $NO_X$, AND $PM_{10}$ EMISSIONS

The BART rule indicates that KCP&L should model the highest actual 24-hour emission rate for each visibility impairing pollutant that occurred during a baseline period. Thus, the $SO_2$, $NO_x$, and $PM_{10}$ emissions that will be modeled to determine the current visibility impacts attributable to La Cygne Unit 1 and Unit 2 are the maximum of the 2002-2004 24-hour highest actual emissions rates. The $SO_2$ and $NO_x$ emission rates will be based on CEMS data. The $PM_{10}$ emission rates will be based on actual fuel data from 2002-2004 and AP-42 emission factors. The $PM_{10}$ emission rates will include both the filterable and condensable fractions. Detailed calculations for the $PM_{10}$ emission rates can be found in Appendix C. The $SO_2$, $NO_x$, and $PM_{10}$ emissions are summarized in Table 4-1.

**TABLE 4-1. $SO_2$, $NO_X$ AND $PM_{10}$ EMISSIONS**

| | $SO_2$ (lb/hr) | $NO_X$ (lb/hr) | $PM_{10}$ (lb/hr) |
|---|---|---|---|
| La Cygne - Unit 1 | 6,151.15 | 11,589.52 | 53.79 |
| La Cygne - Unit 2 | 8,316.15 | 3,543.47 | 94.92 |

### 4.1.2 SPECIATED $PM_{10}$ EMISSIONS

The $PM_{10}$ emissions will be speciated to include the following:

- Coarse particulate matter ($PM_C$)
- Fine particulate matter ($PM_f$)
- Sulfates ($SO_4$)
- Nitrates ($NO_3$)
- Secondary organic aerosols (SOA)
- Elemental carbon (EC)

The $PM_{10}$ emissions will be speciated according to the default speciation profiles prepared by the Federal Land Managers (FLM) for a Cyclone Furnace with Flue Gas Desulfurization (FGD) and ESP

(La Cygne Unit 1) and a dry bottom PC boiler with ESP (La Cygne Unit 2). It should be noted that Unit 1 is a cyclone furnace with wet FGD only; however, there is not an FLM $PM_{10}$ speciation for this type of cyclone boiler. Therefore, the FLM $PM_{10}$ speciation for a Cyclone Furnace with FGD and ESP was used. Since the wet FGD controls PM, this speciation is appropriate for Unit 1. Table 4-2 provides a summary of the speciated emissions.

**TABLE 4-2. HOURLY $PM_{10}$ SPECIATED EMISSIONS**

| | Total PM10 (lb/hr) | SO4 (lb/hr) | $PM_c$ (lb/hr) | $PM_f$ (lb/hr) | SOA (lb/hr) | EC (lb/hr) |
|---|---|---|---|---|---|---|
| La Cygne - Unit 1 | 53.79 | 34.37 | 4.92 | 5.68 | 8.59 | 0.22 |
| La Cygne - Unit 2 | 94.92 | 28.12 | 33.20 | 25.58 | 7.03 | 0.98 |

## 4.2 GEP STACK HEIGHT

Section 6.2.2 of the Guideline on Air Quality Models[1] states the following:

> *"The use of stack height credit in excess of Good Engineering Practice (GEP) stack height or credit resulting from any other dispersion technique is prohibited in the development of emission limitations by 40 CFR 51.118 and 40 CFR 51.164."*

Since this modeling is being used to determine if emissions limitations are needed, stack heights in excess of GEP stack heights should not be used in the modeling. KCP&L has calculated the GEP stack heights of La Cygne Unit 1 and Unit 2 and determined that the actual heights are in excess of GEP stack height.

The EPA provides guidance for determining whether building downwash will occur in *Guideline for Determination of Good Engineering Practice Stack Height.*[2] The minimum stack height not subject to the effects of downwash (called the Good Engineering Practice or GEP stack height) is defined by the following formula:

$$GEP = H + 1.5L$$

Where: GEP = the minimum GEP stack height
H = the height of the structure
L = the lesser dimension of the structure (height or projected width)

Stacks located more than 5L from any building are not subject to the effects of building downwash.

[1] 40 CFR 51, Appendix W

[2] EPA, Office of Air Quality Planning and Standards. *Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised).* Research Triangle Park, North Carolina. EPA 450/4-80-023R. June, 1985.

Calculations for determining the direction-specific downwash parameters and GEP stack height were performed using *BREEZE*™ WAKE/BPIP software, which uses EPA's Building Profile Input Program (BPIP) downwash algorithm. Figure 4.1 shows the stacks and buildings that were included in the BPIP analysis. Since the GEP stack heights are less than the actual stack heights, the stacks will be modeled at GEP stack heights rather than the actual stack heights. A summary of the stack parameters, including GEP and actual stack heights, can be found in Table 4-3. These parameters are only specific to the existing operations; as KCP&L evaluates BART control options, the parameters may be modified for each control option.

**FIGURE 4-1. LA CYGNE STACK AND BUILDING LOCATIONS**

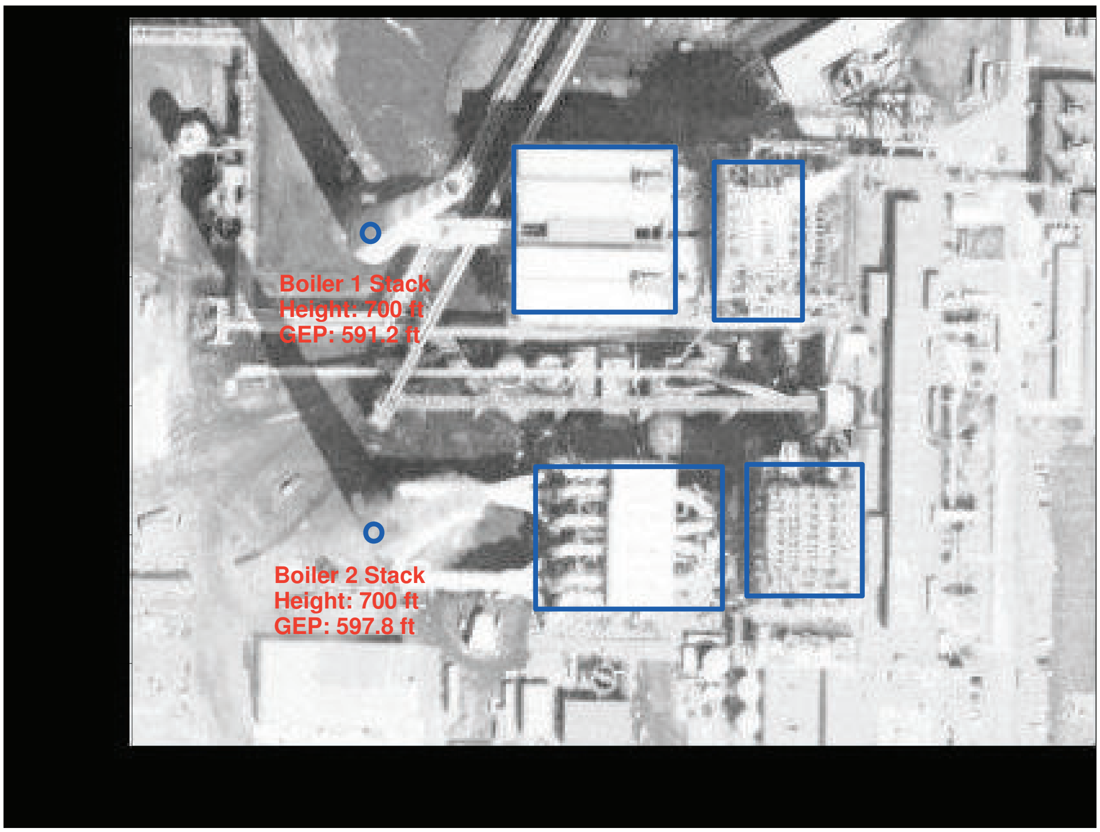



**TABLE 4-3. SUMMARY OF STACK PARAMETERS**

| | La Cygne 1 | La Cygne 2 |
|---|---|---|
| Latitude (degrees) | 38.3486 | 38.3476 |
| Longitude (degrees) | -94.6456 | -94.6456 |
| Actual Stack height (ft) | 700 | 700 |
| GEP Stack height (ft) | 591.2 | 597.8 |
| Stack Diameter (ft) | 23 | 24 |
| Exhaust Velocity (ft/s) | 92.7 | 100.8 |
| Exhaust Temperature (F) | 127 | 281 |

## 4.3 CLASS I AREA RECEPTORS

The National Park Service (NPS) has electronic files for each Class I area available on their website containing the locations and elevations of discrete Class I area receptors. The receptor files for all Class I areas will be downloaded from the NPS website, converted into the LCC WGS84 projection, and incorporated into the CALPUFF model. The receptor locations for the Class I areas are shown in Figures 4-2 through 4-6.

**FIGURE 4-2. HERCULES-GLADES WILDERNESS RECEPTOR LOCATIONS**

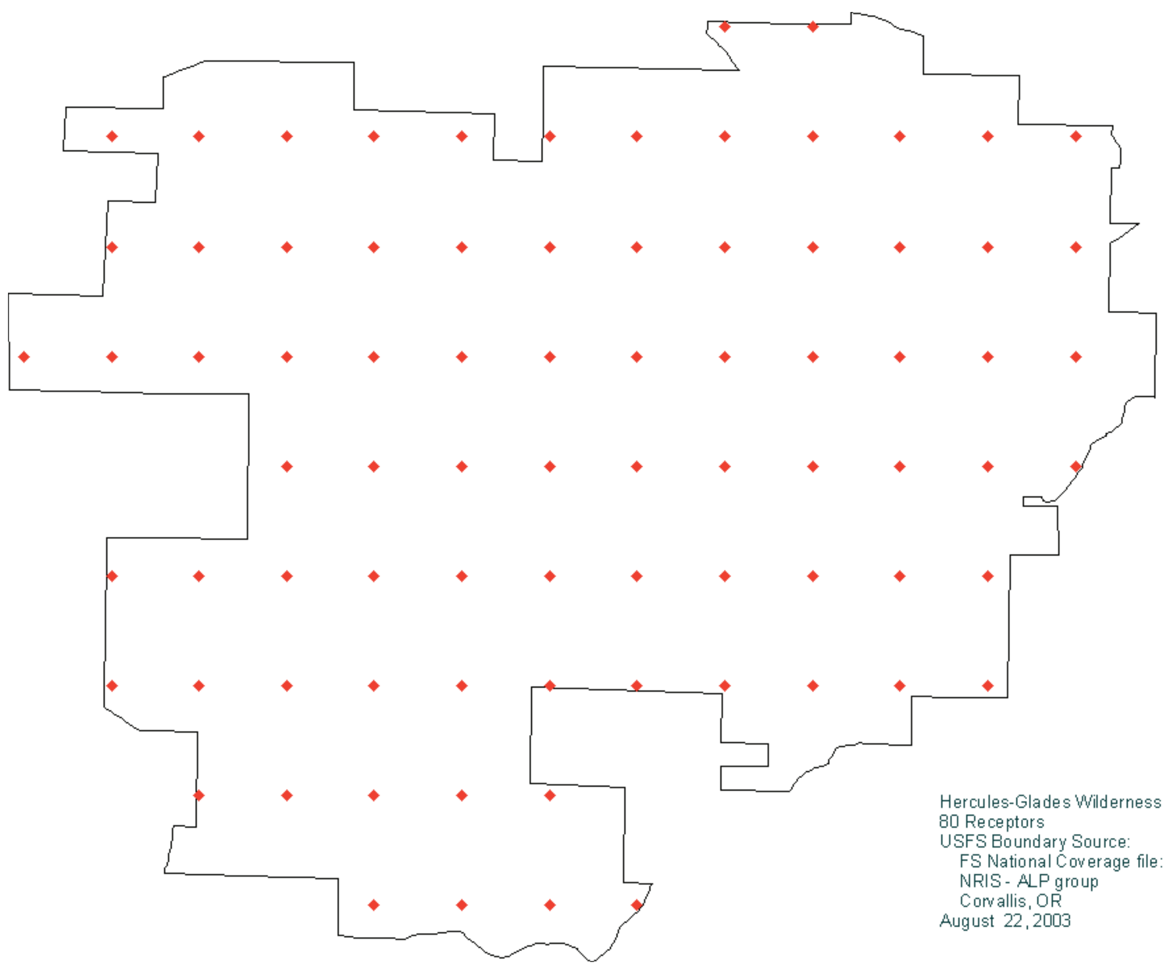


**FIGURE 4-3. WICHITA MOUNTAINS RECEPTOR LOCATIONS**

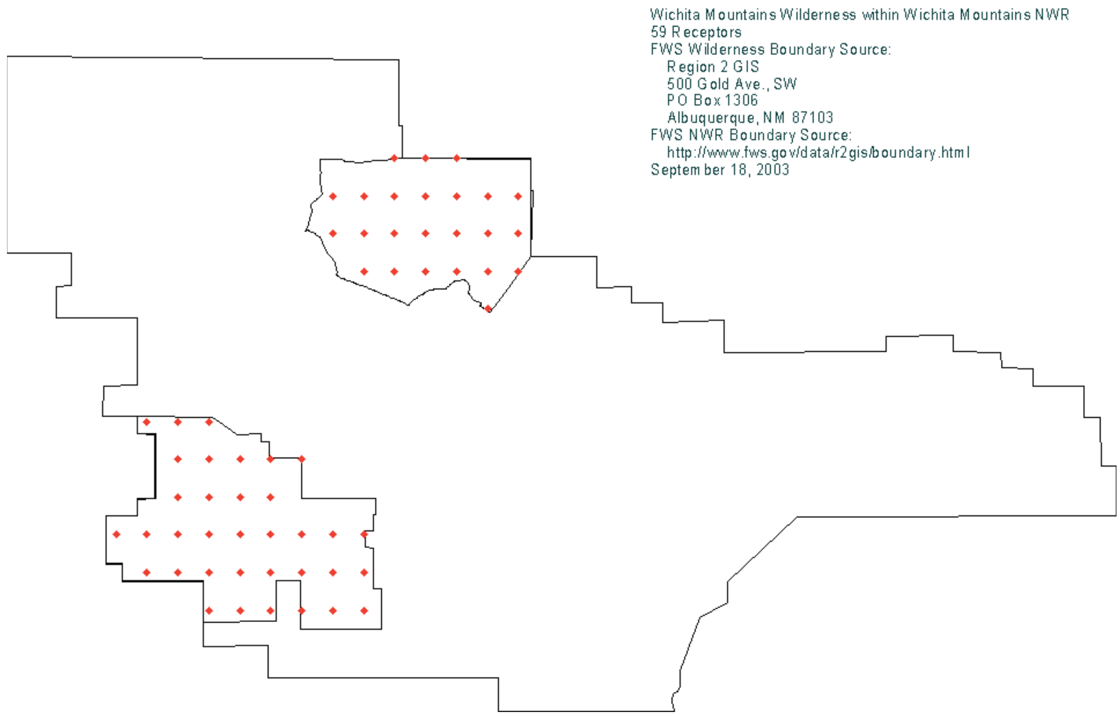


**FIGURE 4-4. UPPER BUFFALO RECEPTOR LOCATIONS**

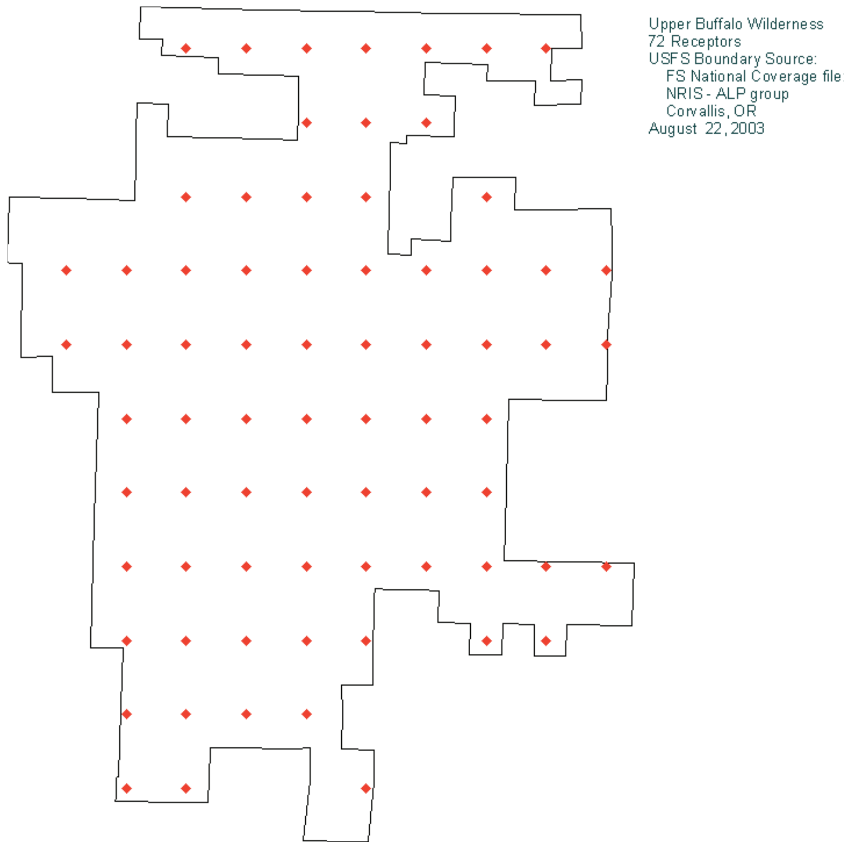



**FIGURE 4-5. CANEY CREEK RECEPTOR LOCATIONS**

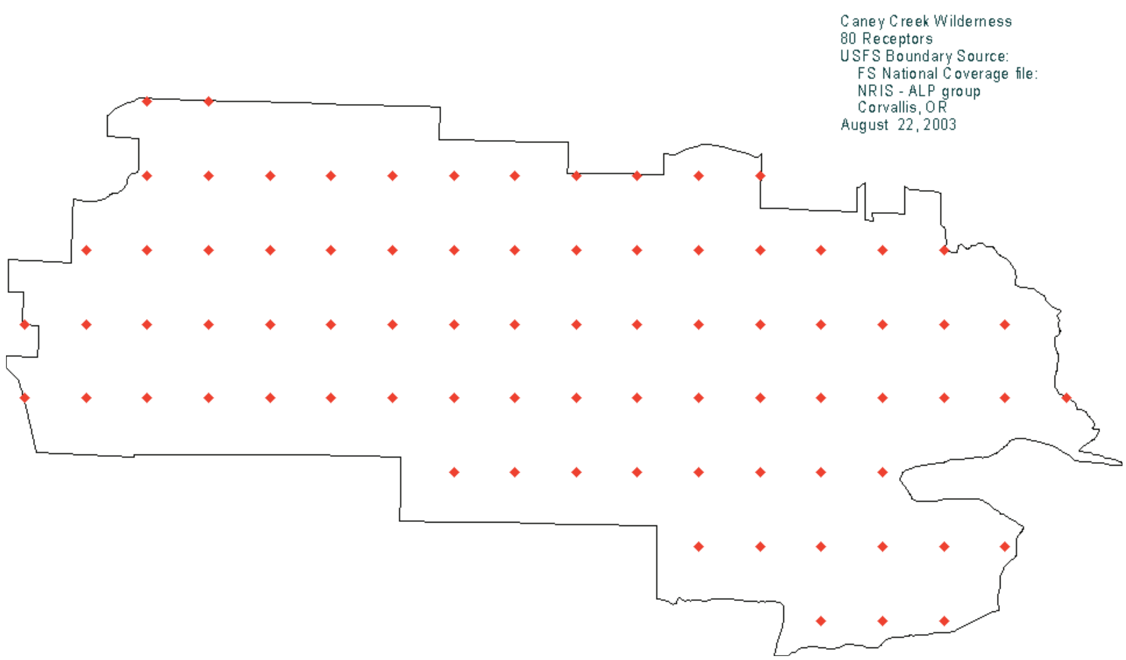
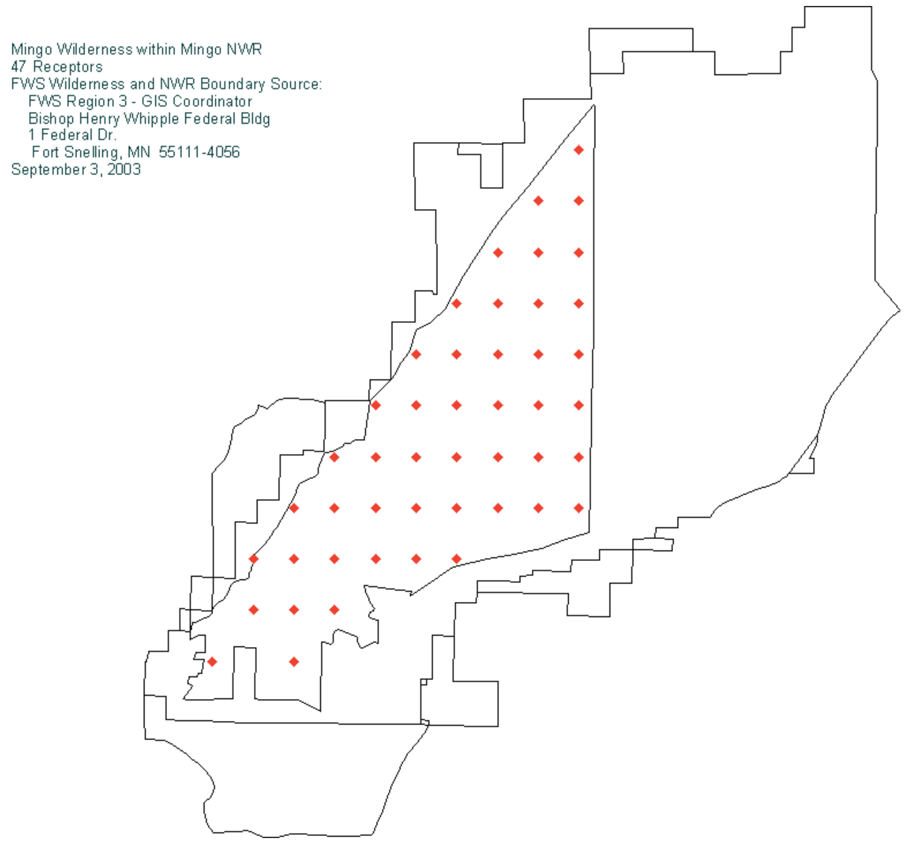


**FIGURE 4-6. MINGO RECEPTOR LOCATIONS**




## 4.4 BACKGROUND OZONE

Background ozone concentrations are required in order to model the photochemical conversion of $SO_2$ and $NO_x$ to sulfates ($SO_4$) and nitrates ($NO_3$). CALPUFF can use either a single background value representative of an area or hourly ozone data from one or more ozone monitoring stations. CENRAP recommends either developing background ozone estimates from ambient monitors located within the particular domain being modeled or developing background ammonia estimates from CENRAP's most recent CMAQ or CAMx simulation for the 2002 base year. KCP&L is proposing to incorporate hourly ozone data from three rural ozone monitors across the state of Kansas. The three monitors are listed in Table 4-4.

**TABLE 4-4. SUMMARY OF OZONE MONITORS**

| Monitor ID | County | Latitude | Longitude |
|---|---|---|---|
| 201910002 (Peck) | Sumner | 37.477 | 97.366 |
| 201950001 (Cedar Bluff) | Trego | 38.770 | 99.764 |
| 20107002 (Mine Creek) | Linn | 38.135 | 94.732 |

Andy Hawkins of KDHE has made available processed ozone data files for 2001 through 2003 containing data from the above referenced stations. KCP&L is proposing to incorporate these files into the CALPUFF model.

## 4.5 BACKGROUND AMMONIA

Background ammonia concentrations are required to model the formation of ammonium sulfates and ammonium nitrates. CENRAP recommends developing background ammonia estimates from CENRAP's most recent CMAQ or CAMx simulation for the 2002 base year. Since CMAQ/CAMx modeled and observed monthly averaged ammonia concentrations exhibit wide spatial variability, CENRAP recommends obtaining separate monthly-averaged ammonia concentrations from CMAQ or CAMx for the CENRAP north, central and south modeling domains, respectively. These would then be used as input to CALPUFF. Since the data from CENRAP's CMAQ and CAMx simulations are not readily available, KCP&L is proposing to use a conservative monthly background concentration of 3 ppb. This background concentration is the value included in CENRAP's protocol as a default background value for the CENRAP region.

## 4.6 SUMMARY OF CALPUFF CONTROL PARAMETERS

Table 4-5 provides a listing of the CALPUFF parameters that KCP&L proposes to use in the modeling analysis. In addition to the parameters that will be used, the table also lists CENRAP's recommended parameters for comparison. In cases where a parameter to be used is different than what CENRAP recommended, a short explanation as to the difference is proved.

**TABLE 4-5. SUMMARY OF CALPUFF INPUTS**

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| METRUN | All model periods in met files will be run | 0 | 0 | |
| IBYR | Starting year | 2001 | Appropriate met year | Years 2001, 2002, 2003 |
| IBMO | Starting month | 1 | 1 | |
| IBDY | Starting day | 1 | 1 | |
| IBHR | Starting hour | 1 | 1 | |
| XBTZ | Base time zone (6 = CST) | 6 | 6 | |
| IRLG | Length of run | 8760 | 8760 | |
| NSPEC | Number of MESOPUFF II chemical species | 10 | 9 | |
| NSE | Number of chemical species to be emitted | 8 | 7 | Appears to be an error in CENRAP's count of the emitted species (only 7 listed in Table B-4 of protocol) |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| ITEST | Program is executed after SETUP phase | 2 | 2 | |
| MRESTART | Do not read or write a restart file during run | 0 | 0 | |
| NRESPD | File written only at last period | 0 | 0 | |
| METFM | CALMET binary file (CALMET.MET) | 1 | 1 | |
| AVET | Averaging time in minutes | 60 | 60 | |
| PGTIME | PG Averaging time in minutes | 60 | 60 | |
| MGAUSS | Gaussian distribution used in near field | 1 | 1 | |
| MCTADJ | Partial plume path terrain adjustment | 3 | 3 | |
| MCTSG | Sub-grid-scale complex terrain not modeled | 0 | 0 | |
| MSLUG | Near-field puffs not modeled as elongated | 0 | 0 | |
| MTRANS | Transitional plume rise modeled | 1 | 1 | |
| MTIP | Stack tip downwash used | 1 | 1 | |
| MSHEAR | (0, 1) Vertical wind shear (not modeled, modeled) | 0 | 0 | |
| MSPLIT | Puffs are not split | 0 | 1 | Included puff splitting due to significant distance between sources and Class I areas |
| MCHEM | MESOPUFF II chemical parameterization scheme | 1 | 1 | |
| MAQCHEM | Aqueous phase transformation not modeled | 0 | 0 | |
| MWET | Wet removal modeled | 1 | 1 | |
| MDRY | Dry deposition modeled | 1 | 1 | |
| MDISP | PG dispersion coefficients | 3 | 3 | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| MTURBVW | Use both $\sigma_v$ and $\sigma_w$ from PROFILE.DAT to compute $\sigma_y$ and $\sigma_z$ (n/a) | 3 | 3 | |
| MDISP2 | PG dispersion coefficients | 3 | 3 | |
| MROUGH | PG $\sigma_y$ and $\sigma_z$ not adjusted for roughness | 0 | 0 | |
| MPARTL | No partial plume penetration of elevated inversion | 1 | 1 | |
| MTINV | Strength of temperature inversion computed from default gradients | 0 | 0 | |
| MPDF | PDF not used for dispersion under convective conditions | 0 | 0 | |
| MSGTIBL | Sub-grid TIBL module not used for shoreline | 0 | 0 | |
| MBCON | Boundary concentration conditions not modeled | 0 | 0 | |
| MFOG | Do not configure for FOG model output | 0 | 0 | |
| MREG | Technical options must conform to USEPA Long Range Transport (LRT) guidance | 1 | 1 | |

| CSPEC | ***CENRAP*** | | | | ***KCP&L*** | | | |
|---|---|---|---|---|---|---|---|---|
| | ***Output Group Species*** | ***Modeled*** | ***Emitted*** | ***Dry Deposition*** | ***Output Group Species*** | ***Modeled*** | ***Emitted*** | ***Dry Deposition*** |
| | $SO_2$ | 1 | 1 | 1 | $SO_2$ | 1 | 1 | 1 |
| | SO4 | 1 | 0 | 2 | SO4 | 1 | 1 | 2 |
| | NOX | 1 | 1 | 1 | NOX | 1 | 1 | 1 |
| | HNO3 | 1 | 0 | 1 | HNO3 | 1 | 0 | 1 |
| | NO3 | 1 | 0 | 2 | NO3 | 1 | 0 | 2 |
| | PMC | 1 | 1 | 2 | PMC | 1 | 1 | 2 |
| | PMF | 1 | 1 | 2 | PMF | 1 | 1 | 2 |
| | EC | 1 | 1 | 2 | EC | 1 | 1 | 2 |
| | SOA | 1 | 1 | 2 | SOA | 1 | 1 | 2 |
| PMAP | Map projection | | UTM | | LCC | | | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| NX | Number of X grid cells in meteorological grid | 66 | 346 | Appropriate for domain and grid spacing |
| NY | Number of Y grid cells in meteorological grid | 66 | 261 | Appropriate for domain and grid spacing |
| NZ | Number of vertical layers in meteorological grid | 10 | 10 | |
| DGRIDKM | Grid spacing (km) | 6 | 2.5 | Refined grid size |
| ZFACE | Cell face heights in meteorological grid (m) | 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000 | 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000 | |
| XORIGKM | Reference X coordinate for SW corner of grid cell of meteorological grid (km) | 5 | 0 | Appropriate for domain |
| YORIGKM | Reference Y coordinate for SW corner of grid cell of meteorological grid (km) | 3327 | 0 | Appropriate for domain |
| IUTMZN | UTM zone of coordinates (NAD83) | 12 | 14 | Appropriate for domain |
| IBCOMP | X index of lower left corner of the computational grid | 1 | 1 | |
| JBCOMP | Y index of lower left corner of the computational grids | 1 | 1 | |
| IECOMP | X index of upper right corner of the computational grid | 66 | 346 | Appropriate for domain |
| JECOMP | Y index of upper right corner of the computational grid | 66 | 261 | Appropriate for domain |
| LSAMP | Sampling grid is not used | F | F | |
| IBSAMP | X index of lower left corner of sampling grid | 1 | 1 | |
| JBSAMP | Y index of lower left corner of sampling grid | 1 | 1 | |
| IESAMP | X index of upper right corner of sampling grid | 66 | 346 | Appropriate for domain |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| JESAMP | Y index of upper right corner of sampling grid | 66 | 261 | Appropriate for domain |
| MESHDN | Nesting factor of sampling grid | 1 | 1 | |
| ICON | Output file CONC.DAT containing concentrations is created | 1 | 1 | |
| IDRY | Output file DFLX.DAT containing dry fluxes is created | 1 | 1 | |
| IWET | Output file WFLX.DAT containing wet fluxes is created | 1 | 1 | |
| IVIS | Output file containing relative humidity data is created | 1 | 1 | |
| LCOMPRS | Perform data compression in output file | T | T | |
| IMFLX | Do not calculate mass fluzes across specific boundaries | 0 | 0 | |
| IMBAL | Mass balances for each species not reported hourly | 0 | 0 | |
| ICPRT | Print concentration fields to output list file | 1 | 1 | |
| IDPRT | Do not print dry flux fields to output list file | 0 | 0 | |
| IWPRT | Do not print wet flux fields to output list file | 0 | 0 | |
| ICFRQ | Concentration fields are printed to output list file every hour | 1 | 1 | |
| IDFRQ | Dry flux fields are printed to output list file every 1 hour | 1 | 1 | |
| IWFRQ | Wet flux fields are printed to output list file every 1 hour | 1 | 1 | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| IPTRU | Units for line printer output are in $g/m^3$ for concentration and $g/m^2/s$ for deposition | 3 | 3 | |
| IMESG | Messages tracking the progress of run written to screen | 2 | 2 | |
| LDEBUG | Logical value for debug output | F | F | |
| IPFDEB | First puff to track | 1 | 1 | |
| NPFDEB | Number of puffs to track | 1 | 1 | |
| NN1 | Meteorological period to start output | 1 | 1 | |
| NN2 | Meteorological period to end output | 10 | 10 | |
| NHILL | Number of terrain features | 0 | 0 | |
| NCTREC | Number of special complex terrain receptors | 0 | 0 | |
| MHILL | Input terrain and receptor data for CTSG hills input in CTDM format | 2 | 2 | |
| XHILL2M | Conversion factor for changing horizontal dimensions to meters | 1 | 1 | |
| ZHILL2M | Conversion factor for changing vertical dimensions to meters | 1 | 1 | |
| XCTDMKM | X origin of CTDM system relative to CALPUFF coordinate system (km) | 0 | 0 | |
| YCTDMKM | Y origin of CTDM system relative to CALPUFF coordinate system (km) | 0 | 0 | |
| SO2 | Diffusivity | 0.1509 | 0.1509 | |
| | Alpha star | 1000 | 1000 | |
| | Reactivity | 8 | 8 | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| | Mesophyll resistance | 0 | 0 | |
| | Henry's Law coefficient | 0.04 | 0.04 | |
| $NO_X$ | Diffusivity | 0.1656 | 0.1656 | |
| | Alpha star | 1 | 1 | |
| | Reactivity | 8 | 8 | |
| | Mesophyll resistance | 5 | 5 | |
| | Henry's Law coefficient | 3.5 | 3.5 | |
| HNO3 | Diffusivity | 0.1628 | 0.1628 | |
| | Alpha star | 1 | 1 | |
| | Reactivity | 18 | 18 | |
| | Mesophyll resistance | 0 | 0 | |
| | Henry's Law coefficient | 8.e-8 | 8.e-8 | |
| SO4-2 | Geomatric mass mean diameter of SO4-2 (µm) | 0.48 | 0.48 | |
| NO3- | Geometric mass mean diameter of NO3- (µm) | 0.48 | 0.48 | |
| PMC | Geometric mass mean diameter of PMC (µm) | 6 | 6 | |
| PMF | Geometric mass mean diameter of PMF (µm) | 0.48 | 0.48 | |
| EC | Geometric mass mean diameter of EC (µm) | 0.48 | 0.48 | |
| SOA | Geometric mass mean diameter of SOA (µm) | 0.48 | 0.48 | |
| RCUTR | Reference cuticle resistance (s/cm) | 30 | 30 | |
| RGR | Reference ground resistance (s/cm) | 10 | 10 | |
| REACTR | Reference pollutant reactivity | 8 | 8 | |
| NINT | Number of particle size intervals for effective particle deposition velocity | 9 | 9 | |
| IVEG | Vegetation in non-irrigated areas is active and unstressed | 1 | 1 | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| $SO_2$ | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 3.21E-05 | 3.E-05 | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 0 | 0 | |
| SO4-2 | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 1.0E-04 | 1.0E-04 | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 3.0E-05 | 3.0E-05 | |
| HNO3 | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 6.0E-05 | 6.0E-05 | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 0 | 0 | |
| NO3- | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 1.0E-04 | 1.0E-04 | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 3.0E-05 | 3.0E-05 | |
| NH3 | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 8.0E-05 | NA | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 0 | NA | |
| PMC | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 1.0E-4 | 1.0E-4 | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 3.0E-05 | 3.0E-05 | |
| PMF | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 1.0E-04 | 1.0E-04 | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 3.0E-05 | 3.0E-05 | |
| EC | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 1.0E-04 | 1.0E-04 | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 3.0E-05 | 3.0E-05 | |
| OC | Scavenging coefficient for liquid precipitation ($s^{-1}$) | 1.0E-04 | 1.0E-04 | |
| | Scavenging coefficient for frozen precipitation ($s^{-1}$) | 3.0E-05 | 3.0E-05 | |
| MOZ | Read ozone background concentrations from ozone.dat file (measured values) | 1 | 1 | |
| BCKO3 | Background ozone concentration (ppb) | 12*40 | NA | Used ozone data file |
| BCKNH3 | Background ammonia concentration (ppb) | 12*3 | 12*3 | |
| RNITE1 | Nighttime NO2 loss rate is %/hour | 0.2 | 0.2 | |
| RNITE2 | Nighttime $NO_X$ loss rate is %/hour | 2 | 2 | |
| RNITE3 | Nighttime HNO3 loss rate is %/hour | 2 | 2 | |
| MH2O2 | Background H2O2 concentrations | 1 | 0 | Need to choose 0 in order to use monthly background value |
| BCKH2O2 | Background monthly H2O2 concentrations | 1 | 12*1 | |
| BCKPMF | Fine particulate concentration for SOA option ($\mu g/m^3$) | 1 | 1 | |
| OFRAC | Organic fraction of fine particulate for SOA option | .2 | 0.15,0.15,0.2,0.2,0.2, 0.2,0.2,0.2,0.2,0.2, 0.2,0.15 | Irrelevant, since MCHEM not equal to 4 |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| VCNX | VOC/$NO_X$ ratio for SOA option | 50 | 50 | |
| SYDEP | Horizontal size of a puff in meters beyond which the time dependant dispersion equation of Heffter is used | 550 | 550 | |
| MHFTSZ | Do not use Heffter formulas for sigma z | 0 | 0 | |
| JSUP | Stability class used to determine dispersion rates for puffs above boundary layer | 5 | 5 | |
| CONK1 | Vertical dispersion constant for stable conditions | 0.01 | 0.01 | |
| CONK2 | Vertical dispersion constant for neutral/stable conditions | 0.1 | 0.1 | |
| TBD | Use ISC transition point for determining the transition point between the Schulman-Scire to Huber-Snyder Building Downwash scheme | 0.5 | 0.5 | |
| IURB1 | Lower range of land use categories for which urban dispersion is assumed | 10 | 10 | |
| IURB2 | Upper range of land use categories for which urban dispersion is assumed | 19 | 19 | |
| ILANDUIN | Land use category for modeling domain | * | * | |
| XLAIIN | Leaf area index for modeling domain | * | * | |
| ZOIN | Roughness length in meters for modeling domain | * | * | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| ELEVIN | Elevation above sea level | * | * | |
| XLATIN | North latitude of station in degrees | - | - | |
| XLONIN | South latitude of station in degrees | - | - | |
| ANEMHT | Anemometer height in meters | 10 | 10 | |
| ISIGMAV | Sigma-v is read for lateral turbulence data | 1 | 1 | |
| IMIXCTDM | Predicted mixing heights are used | 0 | 0 | |
| XMXLEN | Maximum length of emitted slug in meteorological grid units | 1 | 1 | |
| XSAMLEN | Maximum travel distance of slug or puff in meteorological grid units during one sampling unit | 10 | 10 | |
| MXNEW | Maximum number of puffs or slugs released from one source during one time step | 60 | 60 | |
| MXSAM | Maximum number of sampling steps during one time step for a puff or slug | 60 | 60 | |
| NCOUNT | Number of iterations used when computing the transport wind for a sampling step that includes transitional plume rise | 2 | 2 | |
| SYMIN | Minimum sigma y in meters for a new puff or slug | 1 | 1 | |
| SZMIN | Minimum sigma z in meters for a new puff or slug | 1 | 1 | |
| SVMIN | Minimum lateral turbulence velocities (m/s) | 0.5 | 0.5 | |
| SWMIN | Minimum vertical turbulence velocities (m/s) | 0.20, 0.12, 0.08, 0.06, 0.03, 0.016 | 0.20, 0.12, 0.08, 0.06, 0.03, 0.016 | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| WSCALM | Minimum non-calm wind speeds (m/s) | 0.5 | 0.5 | |
| XMAXZI | Maximum mixing height (m) | 3000 | 3000 | |
| XMINZI | Minimum mixing height (m) | 20 | 20 | |
| SL2PF | Maximum σy/puff length | 10 | 10 | |
| PLXO | Wind speed power-law exponents | 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 | 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 | |
| WSCAT | Upper bounds of 1st 5 wind speed classes | 1.54, 3.09, 5.14, 8.23, 10.80 | 1.54, 3.09, 5.14, 8.23, 10.80 | |
| PGGO | Potential temp gradients PG E & F (deg/km) | 0.020, 0.035 | 0.020, 0.035 | |
| CDIV | Divergence criterion for dw/dz (1/s) | 0.01 | 0.01 | |
| PPC | Plume path coefficients (only if MCTADJ = 3) | 0.5, 0.5, 0.5, 0.5, 0.35, 0.35 | 0.5, 0.5, 0.5, 0.5, 0.35, 0.35 | |
| NSPLIT | Number of puffs when split | 3 | 3 | |
| IRESPLIT | Hours when puff is eligible to split | 1900 | Hour 19 | Should be by hour of day – 1900 is hour 19 |
| ZISPLIT | Previous hours minimum mixing height, m | 100 | 100 | |
| ROLDMAX | Previous max mixing height/current height ratio, must be less than this value to allow puff to split | 0.25 | 0.25 | |
| NSPLITH | Number of puffs resulting from a split | 5 | 5 | |
| SYSPLITH | Minimum sigma-y of puff before it may split | 1.0 | 1.0 | |
| SHSPLITH | Minimum puff elongation rate from wind shear before puff may split | 2.0 | 2.0 | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| CNSPLITH | Minimum species concentration before a puff may split | 1.0E-07 | 1.0E-07 | |
| EPSSLUG | Criterion for SLUG sampling | 1.0E-04 | 1.0E-04 | |
| EPSAREA | Criterion for area source integration | 1.0E-06 | 1.0E-06 | |
| DSRISE | Trajectory step length for numerical site algorithm | 1.0 | 1.0 | |
| NPT1 | Number of point sources with constant stack parameters or variable emission rate scale factors | Varies by scenario | Varies by scenario | |
| IPTU | Units for point source emission rates are g/s | 1 | 3 | Used different units (3 = lb/hr) |
| NSPT1 | Number of source-species combinations with variable emissions scaling factors | - | - | |
| NPT2 | Number of point sources with variable emission parameters provided in external file | - | - | |
| MISC | Other point source inputs include stack height, stack diameter, exit temperature, exit velocity, downwash flag and emissions by species | - | - | |
| NAR1 | Number of polygon area sources | Varies by scenario | 0 | None modeled |
| IARU | Units for area source emission rates are $g/m^2/s$ | 1 | 1 | |
| NSAR1 | Number of source species combinations with variable emissions scaling factors | - | - | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| NAR2 | Number of buoyant polygon area sources with variable location and emission parameters | - | - | |
| NLN2 | Number of buoyant line sources with variable location and emission parameters | - | 0 | None modeled |
| NLINES | Number of buoyant line sources | - | - | |
| ILNU | Units for line source emission rates in g/s | - | - | |
| NSLN1 | Number of source-species combinations with variable emissions scaling factors | - | - | |
| MXNSEG | Maximum number of segments used to model each line | - | - | |
| NLRISE | Number of distance at which transitional rise is computed | - | - | |
| XL | Average line source length (m) | - | - | |
| HBL | Average height of line source height (m) | - | - | |
| WBL | Average building width (m) | - | - | |
| WML | Average line source width (m) | - | - | |
| DXL | Average separation between buildings (m) | - | - | |
| FPRIMEL | Average buoyancy parameter (m4/s3) | - | - | |
| NVL1 | Number of volume sources | - | 0 | None modeled |
| IVLU | Units for volume source emission rates in grams/second | - | - | |

| CALPUFF Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| NSVL1 | Number of source-species combinations with variable emissions scaling factors | - | - | |
| IGRDVL | Gridded volume source data is not used | - | - | |
| VEFFHT | Effective height of emissions (m) | - | - | |
| VSIGYI | Initial sigma-y value | - | - | |
| VSIGZI | Initial sigma-z value | - | - | |
| NREC | Number of non-gridded receptors | 5630 | 338 | |

# 5. CALPOST

KCP&L will conduct a three-year CALPOST analysis to determine the change in light extinction caused by La Cygne Unit 1 and Unit 2 when compared to a natural background. The CALPOST model requires the input of concentration data output by CALPUFF.

## 5.1 LIGHT EXTINCTION ALGORITHM

KCP&L will utilize EPA's currently approved algorithm for reconstructing light extinction (as opposed to the new equation for reconstructing light extinction recommended by the IMPROVE Steering Committee). The light extinction equation is provided below.

$$b_{ext} = 3*f(RH)*[(NH_4)_2SO_4] + 3*f(RH)*[NH_4NO3] + 4*[OC] + 1*[PM_f] + 0.6*[PM_c] + 10*[EC] + b_{Ray}$$

The algorithm will be used to calculate the daily light extinction attributable to La Cygne Unit 1 and Unit 2 and light extinction attributable to a natural background. The change in deciviews based on the source and background light extinctions will be evaluated using the equation below.

$$\Delta dv = 10*\ln\left[\frac{b_{ext,\ background} + b_{ext,\ source}}{b_{ext,\ background}}\right]$$

## 5.2 CALPOST PROCESSING METHOD

KCP&L will use CALPOST Method 6, which calculates hourly light extinction impacts for the source and background using monthly average relative humidity adjustment factors. KCP&L will use monthly Class I area-specific relative humidity adjustment factors based on the centroid of the Class I areas as included in Table A-3 of EPA's *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program*. The factors for the Class I areas in this analysis are provided in Table 5-1.

**TABLE 5-1. MONTHLY HUMIDITY FACTORS**

| Class I Area | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hercules-Glades | 3.2 | 2.9 | 2.7 | 2.7 | 3.3 | 3.3 | 3.3 | 3.3 | 3.4 | 3.1 | 3.1 | 3.3 |
| Wichita Mountains | 2.7 | 2.6 | 2.4 | 2.4 | 3.0 | 2.7 | 2.3 | 2.5 | 2.9 | 2.6 | 2.7 | 2.8 |
| Upper Buffalo | 3.3 | 3.0 | 2.7 | 2.8 | 3.4 | 3.4 | 3.4 | 3.4 | 3.6 | 3.3 | 3.2 | 3.3 |
| Caney Creek | 3.4 | 3.1 | 2.9 | 3.0 | 3.6 | 3.6 | 3.4 | 3.4 | 3.6 | 3.5 | 3.4 | 3.5 |
| Mingo | 3.3 | 3.0 | 2.8 | 2.6 | 3.0 | 3.2 | 3.3 | 3.5 | 3.5 | 3.1 | 3.4 | 3.3 |

## 5.3 NATURAL BACKGROUND

KCP&L will use EPA's default average annual aerosol concentrations for the western half of the U.S. that are included in Table 2-1 of EPA's *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program* for Wichita Mountains. KCP&L will use EPA's default average annual aerosol concentrations for the eastern half of the U.S. that are included in Table 2-1 of EPA's *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program* for Upper Buffalo, Caney Creek, Hercules Glades and Mingo. The annual average concentrations are provided in Table 5-2.

**TABLE 5-2. DEFAULT AVERAGE ANNUAL NATURAL BACKGROUND LEVELS**

| **Component** | **Average Annual Natural Background – Western ($\mu g/m^3$)** | **Average Annual Natural Background – Eastern ($\mu g/m^3$)** |
|---|---|---|
| Ammonium Sulfate | 0.12 | 0.23 |
| Ammonium Nitrate | 0.1 | 0.1 |
| Organic Carbon Mass | 0.47 | 1.4 |
| Elemental Carbon | 0.02 | 0.02 |
| Soil | 0.5 | 0.5 |
| Coarse Mass | 3 | 3 |

## 5.4 SUMMARY OF CALPOST CONTROL PARAMETERS

Table 5-3 provides a listing of the CALPOST parameters that KCP&L proposes to use in the modeling analysis. In addition to the parameters that will be used for the modeling, the table also lists CENRAP's recommended parameters for comparison. In cases where a parameter to be used is different than what CENRAP recommended, a short explanation as to the difference is proved.

**TABLE 5-3. SUMMARY OF CALPOST INPUTS**

| CALPOST Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| ISYR | Starting year | 2001 | Appropriate met year | Years 2001, 2002, 2003 |
| ISMO | Starting month | 1 | 1 | |
| ISDY | Starting day | 1 | 1 | |
| ISHR | Starting hour | 0 | 1 | All CALPUFF periods will be included |
| NPER | Number of periods to process | 8760 | 8760 | |
| NREP | Process every hour of data? 1 = yes | 1 | 1 | |
| ASPEC | Process species for visibility | VISIB | VISIB | |

| CALPOST Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| ILAYER | Layer/deposition code; 1 for CALPUFF concentrations | 1 | 1 | |
| A | Scaling factor, slope | 0 | 0 | |
| B | Scaling factor, intercept | 0 | 0 | |
| LBACK | Add hourly background concentrations of fluxes? | F | F | |
| LG | Process gridded receptors? | F | F | |
| LD | Process discrete receptors? | T | T | |
| LCT | Process complex terrain receptors? | F | F | |
| LDRING | Report receptor ring results? | F | F | |
| NDRECP | Select all discrete receptors | -1 | Varies | As appropriate for Class I area being analyzed |
| IBGRID | X index of LL corner of receptor grid | -1 | -1 | |
| JBGRID | Y index of LL corner of receptor grid | -1 | -1 | |
| IEGRID | X index of UR corner of receptor grid | -1 | -1 | |
| JEGRID | Y index of UR corner of receptor grid | -1 | -1 | |
| NGONOFF | Number of gridded receptor rows | 0 | 0 | |
| NGXRECP | Exclude specific gridded receptors, Yes = 0 | 0 | 0 | |
| RHMAX | Maximum RH% used in particle growth curve | 95 | 95 | |
| LVSO4 | Compute light extinction for sulfate? | T | T | |
| LVNO3 | Compute light extinction for nitrate? | T | T | |
| LVOC | Compute light extinction for organic carbon? | T | T | |

| CALPOST Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| LVMPC | Compute light extinction for coarse particles? | T | T | |
| LVMPF | Compute light extinction for fine particles? | T | T | |
| LVEC | Compute light extinction for elemental carbon? | T | T | |
| LVBK | Include background in extinction calculation? | T | T | |
| SPECPMC | Coarse particulate species | PMC | PMC | |
| SPECPMF | Fine particulate species | $PM_{10}$ | PMF | Notation difference |
| EEPMC | Extinction efficiency for coarse particulates | 0.6 | 0.6 | |
| EEPMF | Extinction efficiency for fine particles? | 1.0 | 1.0 | |
| EEPMCBCK | Extinction efficiency for coarse part. Background | 0.6 | 0.6 | |
| EESO4 | Extinction efficiency for ammonium sulfate | 3.0 | 3.0 | |
| EENO3 | Extinction efficiency for ammonium nitrate | 3.0 | 3.0 | |
| EEOC | Extinction efficiency for organic carbon | 4.0 | 4.0 | |
| EESOIL | Extinction efficiency for soil | 1.0 | 1.0 | |
| EEEC | Extinction efficiency for elemental carbon | 10.0 | 10.0 | |
| MVISBK | Method 6 for background light extinction | 6 | 6 | |
| BEXTBTBK | Background extinction for MVISBK=1 | 12 | Not Used | Not necessary since MVISBK=6 |
| RHFRAC | % of particles affected by RH | 10 | Not Used | Not necessary since MVISBK=6 |

| CALPOST Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| RHFAC | Extinction coefficients for modeled and background hygroscopic species computed using EPA (2003) monthly RH adjustment factors | Depends on Class I Area | See Table 5-1 | As appropriate for Class I area |
| BKSO4 | Background sulfate extinction coeff - west | 0.12 | 0.12 | Used for Wichita Mountains |
| BKNO3 | Background nitrate extinction coeff – west | 0.10 | 0.10 | Used for Wichita Mountains |
| BKPMC | Background coarse part. extinction coeff – west | 3.00 | 3.00 | Used for Wichita Mountains |
| BKSOC | Background organic carbon extinction coeff – west | 0.47 | 0.47 | Used for Wichita Mountains |
| BKSOIL | Background soil extinction coeff – west | 0.50 | 0.50 | Used for Wichita Mountains |
| BKSEC | Background elemental carbon extinction coeff – west | 0.02 | 0.02 | Used for Wichita Mountains |
| BKSO4 | Background sulfate extinction coeff – east | 0.23 | 0.23 | Used for Upper Buffalo, Caney Creek, Hercules Glades and Mingo |
| BKNO3 | Background nitrate extinction coeff – east | 0.10 | 0.10 | Used for Upper Buffalo, Caney Creek, Hercules Glades and Mingo |
| BKPMC | Background sulfate extinction coeff – west | 3.00 | 3.00 | Used for Upper Buffalo, Caney Creek, Hercules Glades and Mingo |
| BKSOC | Background organic carbon extinction coeff – east | 1.40 | 1.40 | Used for Upper Buffalo, Caney Creek, Hercules Glades and Mingo |
| BKSSOIL | Background soil extinction coeff – east | 0.50 | 0.50 | Used for Upper Buffalo, Caney Creek, Hercules Glades and Mingo |
| BKSEC | Background elemental carbon extinction coeff – east | 0.02 | 0.02 | Used for Upper Buffalo, Caney Creek, Hercules Glades and Mingo |

| CALPOST Variable | Description | Value Included in CENRAP Protocol | Value KCP&L Will Use | Notes |
|---|---|---|---|---|
| BEXTRAY | Extinction due to Rayleigh scattering (1/Mm) | 10.0 | 10.0 | |
| LDOC | Print documenta-tion image? | F | F | |
| IPTRU | Print output units for concentrations and for deposition | 3 | 1 | Units preference |
| L1HR | Report 1 hr averaging times | F | F | |
| L3HR | Report 3 hr averaging times | F | F | |
| L24HR | Report 24 hr averaging times | T | T | |
| LRUNL | Report run-length averaging times | F | F | |
| LT50 | Top 50 table | F | F | |
| LTOPN | Top N table | F | F | |
| NTOP | Number of Top-N values at each receptor | 4 | 4 | |
| ITOP | Ranks of Top-N values at each receptor | 1,2,3,4 | 1,2,3,4 | |
| LEXCD | Threshold exceedances counts | F | F | |
| THRESH1 | Averaging time threshold for 1 hr averages | -1 | -1 | |
| THRESH3 | Averaging time threshold for 3 hr averages | -1 | -1 | |
| THRESH24 | Averaging time threshold for 24 hr averages | -1 | -0.2 | Lower threshold – no effect on results |
| THRESHN | Averaging time threshold for NAVG-hr averages | -1 | -1 | |
| NDAY | Accumulation period, days | 0 | 0 | |
| NCOUNT | Number of exceedances allowed | 1 | 1 | |
| LECHO | Echo option | F | F | |
| LTIME | Time series option | F | F | |
| LPLT | Plot file option | F | F | |
| LGRD | Use grid format instead of DATA format | F | F | |
| LDEBUG | Output information for debugging? | F | F | |

## 5.5 Evaluating BART

KCP&L will perform modeling as outlined in this protocol to determine the visibility impacts based on the existing emission rates and exhaust characteristics for La Cygne Unit 1 and Unit 2. The modeling methods outlined in this protocol will also be used in the evaluation of BART control options. Since we are in the process of evaluating BART control options, specific data related to the control options are not provided in this protocol. KCP&L will provide data specific to the control options as part of the controls analysis.

# APPENDIX A

## GEOPHYSICAL DATA

### TABLE A-1. LAND USE DATA USED IN ANALYSIS

**1:250,000 Scale Data**

Abilene
Ardmore
Belleville
Beloit
Blytheville
Clinton
Dallas
Decatur
Dyersburg
El Dorado
Enid
Fort Smith
Great Bend
Greenwood
Harrison
Helena
Hutchinson
Jackson
Jefferson City
Joplin
Kansas City
Lawrence
Lawton
Little Rock
Manhattan
Memphis
Meridian
Moberly
Oklahoma City
Paducah
Poplar Bluff
Pratt
Quincy
Rolla
Sherman
Shreveport
Springfield
St. Louis
Texarkana
Tulsa
Tupelo
Tyler
West Point
Wichita
Wichita Falls
Woodward

**1:100,000 Scale Data**

Antlers
Conway
DeQueen
Fly Gap Mountains
McAlester
Mena
Mountainview
Russellville

### TABLE A-2. TERRAIN DATA USED IN ANALYSIS

**1:250,000 Scale Data**

| | | |
|---|---|---|
| Abilene-E | Hutchinson-E | Pratt-E |
| Abilene-W | Hutchinson-W | Pratt-W |
| Ardmore-E | Jackson-E | Quincy-E |
| Ardmore-W | Jackson-W | Quincy-W |
| Belleville-E | Jefferson City-E | Rolla-E |
| Belleville-W | Jefferson City-W | Rolla-W |
| Beloit-E | Joplin-E | Russellville-E |
| Beloit-W | Joplin-W | Russellville-W |
| Blytheville-E | Kansas City-E | Sherman-E |
| Blytheville-W | Kansas City-W | Sherman-W |
| Clinton-E | Lawrence-E | Shreveport-E |
| Clinton-W | Lawrence-W | Shreveport-W |
| Dallas-E | Lawton-E | Springfield-E |
| Dallas-W | Lawton-W | Springfield-W |
| Decatur-E | Little Rock-E | Saint Louis-E |
| Decatur-W | Little Rock-W | Saint Louis-W |
| Dyersburg-E | Manhattan-E | Texarkana-E |
| Dyersburg-W | Manhattan-W | Texarkana-W |
| El Dorado-E | McAlester-E | Tulsa-E |
| El Dorado-W | McAlester-W | Tulsa-W |
| Enid-E | Memphis-E | Tupelo-E |
| Enid-W | Memphis-W | Tupelo-W |
| Fort Smith-E | Meridian-E | Tyler-E |
| Fort Smith-W | Meridian-W | Tyler-W |
| Great Bend-E | Moberly-E | West Point-E |
| Great Bend-W | Moberly-W | West Point-W |
| Greenwood-E | Oklahoma City-E | Wichita Falls-E |
| Greenwood-W | Oklahoma City-W | Wichita Falls-W |
| Harrison-E | Paducah-E | Wichita-E |
| Harrison-W | Paducah-W | Wichita-W |
| Helena-E | Poplar Bluff-E | Woodward-E |
| Helena-W | Poplar Bluff-W | Woodward-W |

**TABLE B-1. LIST OF SURFACE METEOROLOGCAL STATIONS**

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 3927 | DALLAS-FORT WORTH INTL AP | KDFW | 32.900 | -97.017 | 217.594 | -110.664 |
| 3928 | WICHITA MID-CONTINENT AP | KICT | 37.650 | -97.433 | 168.277 | 415.757 |
| 3945 | COLUMBIA REGIONAL AIRPORT | KCOU | 38.817 | -92.217 | 616.499 | 566.49 |
| 3947 | KANSAS CITY INT'L ARPT | KMCI | 39.300 | -94.717 | 397.998 | 606.872 |
| 13930 | WHITEMAN AFB | KSZL | 38.717 | -93.550 | 502.081 | 547.665 |
| 13957 | SHREVEPORT REGIONAL ARPT | KSHV | 32.450 | -93.817 | 518.947 | -148.434 |
| 13959 | WACO REGIONAL AP | KACT | 31.617 | -97.233 | 200.571 | -253.861 |
| 13962 | ABILENE REGIONAL AP | KABI | 32.417 | -99.683 | -31.46 | -166.963 |
| 13964 | FORT SMITH REGIONAL AP | KFSM | 35.333 | -94.367 | 450.826 | 168.614 |
| 13966 | WICHITA FALLS MUNICIPAL ARPT | KSPS | 33.983 | -98.500 | 78.106 | 7.4 |
| 13967 | OKLAHOMA CITY WILL ROGERS WOR | KOKC | 35.383 | -97.600 | 158.172 | 163.934 |
| 13968 | TULSA INTERNATIONAL AIRPORT | KTUL | 36.200 | -95.883 | 310.224 | 258.752 |
| 13969 | PONCA CITY MUNICIPAL AP | KPNC | 36.733 | -97.100 | 199.91 | 314.65 |
| 13977 | TEXARKANA WEBB FIELD | KTXK | 33.450 | -94.000 | 495.621 | -38.391 |
| 13984 | CONCORDIA BLOSSER MUNI AP | KCNK | 39.550 | -97.650 | 145.489 | 626.359 |
| 13989 | EMPORIA MUNICIPAL AP | KEMP | 38.333 | -96.183 | 275.593 | 494.432 |
| 13995 | SPRINGFIELD REGIONAL ARPT | KSGF | 37.233 | -93.383 | 526.725 | 384.127 |
| 13996 | TOPEKA MUNICIPAL AP | KTOP | 39.067 | -95.633 | 320.318 | 577.594 |
| 72244 | TYLER/POUNDS FLD | KTYR | 32.350 | -95.400 | 370.978 | -166.863 |
| 72249 | NACOGDOCHES (AWOS) | KOCH | 31.583 | -94.717 | 439.217 | -249.285 |
| 72258 | COX FLD | KPRX | 33.633 | -95.450 | 360.508 | -24.527 |
| 72341 | MEMORIAL FLD | KHOT | 34.467 | -93.100 | 571.592 | 79.365 |
| 72344 | FAYETTEVILLE DRAKE FIELD | KFYV | 36.000 | -94.167 | 464.929 | 243.488 |
| 72349 | JOPLIN MUNICIPAL AP | KJLN | 37.150 | -94.500 | 428.648 | 369.387 |
| 72352 | ARDMORE | K1F0 | 34.150 | -97.117 | 205.042 | 27.981 |
| 72445 | KIRKSVILLE REGIONAL AP | KIRK | 40.100 | -92.550 | 577.7 | 706.619 |
| 72449 | ST JOSEPH ROSECRANS MEMORIAL | KSTJ | 39.767 | -94.900 | 379.885 | 657.971 |
| 72450 | CHANUTE MARTIN JOHNSON AP | KCNU | 37.667 | -95.483 | 339.483 | 422.786 |
| 72455 | MANHATTAN RGNL | KMHK | 39.133 | -96.667 | 230.987 | 581.961 |
| 72458 | SALINA MUNICIPAL AP | KSLN | 38.817 | -97.667 | 145.454 | 544.915 |
| 93950 | MCALESTER MUNICIPAL AP | KMLC | 34.900 | -95.783 | 324.515 | 114.893 |
| 93986 | HOBART MUNICIPAL AP | KHBR | 35.000 | -99.050 | 27.099 | 120.026 |
| 72439 | QUINCY MUNICIPAL BALDWIN FLD | KUIN | 39.900 | -91.200 | 694.052 | 693.367 |
| 72439 | SPRINGFIELD CAPITOL AP | KSPI | 39.800 | -89.600 | 831.037 | 694.973 |
| 72433 | BELLEVILLE SCOTT AFB | KBLV | 38.500 | -89.800 | 828.344 | 549.557 |

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 72531 | KAHOKIA/ST. LOUIS | KCPS | 38.500 | -90.100 | 802.399 | 547.016 |
| 72445 | JEFFERSON CITY MEM | KJEF | 38.500 | -92.100 | 629.243 | 532.143 |
| 72445 | KAISER MEM | KAIZ | 38.100 | -92.500 | 597.734 | 485.303 |
| 72445 | SEDALIA MEM | KDMO | 38.700 | -93.100 | 541.118 | 548.219 |
| 72445 | VICHY ROLLA NATL APT | KVIH | 38.100 | -91.700 | 667.423 | 490.56 |
| 72445 | FARMINGTON APT | KFAM | 37.700 | -90.400 | 784.689 | 456.128 |
| 72433 | CARBONDALE | KMDH | 37.700 | -89.200 | 889.555 | 466.564 |
| 72348 | CAPE GIRARDEAU MUNICIPAL APT | KCGI | 37.200 | -89.500 | 869.018 | 408.63 |
| 72435 | PADUCAH BARKLEY REG AP | KPAH | 37.000 | -88.700 | 941.785 | 394.085 |
| 72330 | POPLAR BLUFF | KPOF | 36.700 | -90.400 | 794.99 | 345.628 |
| 72334 | DYERSBURG MUN AP | KDYR | 36.000 | -89.400 | 891.548 | 277.081 |
| 72340 | WALNUT RIDGE | KARG | 36.100 | -90.900 | 756.52 | 275.288 |
| 72344 | BATESVILLE | KBVX | 35.700 | -91.600 | 697.546 | 225.767 |
| 72340 | JONESBORO MUNICIPAL APT | KJBR | 35.800 | -90.600 | 786.334 | 244.532 |
| 72334 | JACKSON MCKELLAR-SIPES REGL | KMKL | 35.600 | -88.900 | 940.995 | 237.698 |
| 72334 | MEMPHIS INTL APT | KMEM | 35.000 | -89.900 | 857.761 | 162.112 |
| 72341 | STUTTGART | KSGT | 34.600 | -91.500 | 716.472 | 104.798 |
| 72341 | PINE BLUFF/GRIDER | KPBF | 34.100 | -91.900 | 684.322 | 46.538 |
| 72340 | LITTLE ROCK ADAMS FIELD | KLIT | 34.700 | -92.200 | 651.867 | 110.892 |
| 72340 | LITTLE ROCK AFB | KLRF | 34.900 | -92.100 | 659.299 | 133.715 |
| 72344 | FLIPPIN | KFLP | 36.300 | -92.400 | 620.853 | 286.681 |
| 72531 | DECATUR | KDEC | 39.800 | -88.800 | 898.976 | 702.162 |
| 72433 | MOUNT VERNON | KMVN | 38.300 | -88.800 | 917.197 | 536.538 |
| 72434 | ST. LOUIS LAMBERT INTL APT | KSTL | 38.700 | -90.300 | 783.013 | 567.477 |

**TABLE B-2. LIST OF PRECIPITATION METEOROLOGICAL STATIONS**

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 30130 | ALUM FORK | ALUM | 34.800 | -92.850 | 591.935 | 117.768 |
| 30178 | ANTOINE | ANTO | 34.033 | -93.417 | 545.626 | 29.461 |
| 30220 | ARKADELPHIA 2 N | ARKA | 34.150 | -93.050 | 578.461 | 44.534 |
| 30764 | BLAKELY MOUNTAIN DAM | BLAK | 34.567 | -93.200 | 561.75 | 89.82 |
| 30832 | BOONEVILLE 3 SSE | BOON | 35.100 | -93.917 | 493.003 | 144.997 |
| 30900 | BRIGGSVILLE | BRIG | 34.933 | -93.500 | 531.902 | 128.745 |
| 31152 | CAMDEN 1 | CAMD | 33.600 | -92.817 | 604.003 | -14.996 |
| 31457 | CLARKSVILLE 6 NE | CLAR | 35.533 | -93.400 | 536.873 | 195.774 |
| 31952 | DE QUEEN DAM | DE Q | 34.100 | -94.367 | 457.937 | 31.902 |
| 32020 | DIERKS DAM | DIER | 34.150 | -94.083 | 483.655 | 38.834 |
| 32544 | FOREMAN | FORE | 33.717 | -94.383 | 458.602 | -10.703 |
| 32574 | FORT SMITH MU, OK | FORT | 35.333 | -94.367 | 450.855 | 168.653 |
| 33165 | HARRISON BOONE CNTY AP | HARR | 36.267 | -93.157 | 553.576 | 278.374 |
| 34185 | LEWISVILLE | LEWI | 33.367 | -93.567 | 536.29 | -45.314 |

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 34548 | MAGNOLIA 3 N | MAGN | 33.333 | -93.250 | 565.86 | -47.199 |
| 34756 | MENA | MENA | 34.567 | -94.267 | 464.388 | 84.135 |
| 35200 | NIMROD DAM | NIMR | 34.950 | -93.167 | 562.061 | 132.486 |
| 35228 | NORFORK DAM | NORF | 36.249 | -92.256 | 634.101 | 282.023 |
| 35908 | PRESCOTT | PRES | 33.800 | -93.383 | 550.293 | 3.781 |
| 37048 | TEXARKANA | TEXA | 33.450 | -94.000 | 495.621 | -38.391 |
| 37488 | WALDRON | WALD | 34.900 | -94.100 | 477.588 | 121.905 |
| 140326 | ARLINGTON | ARLI | 37.900 | -98.267 | 94.684 | 442.364 |
| 141233 | CALDWELL | CALD | 37.034 | -97.616 | 153.468 | 347.056 |
| 141427 | CHANUTE FAA AIRPORT | CHAN | 37.670 | -95.484 | 339.366 | 423.145 |
| 141767 | CONCORDIA BLOSSER MUNI | CONC | 39.551 | -97.651 | 145.415 | 626.512 |
| 141867 | COUNCIL GROVE LAKE | COUN | 38.675 | -96.526 | 244.636 | 531.493 |
| 143997 | IONIA | IONI | 39.661 | -98.348 | 85.529 | 637.868 |
| 144341 | KIOWA | KIOW | 37.017 | -98.485 | 76.494 | 344.138 |
| 145063 | MARYSVILLE | MARY | 39.833 | -96.633 | 231.722 | 659.797 |
| 145306 | MILFORD LAKE | MILF | 39.075 | -96.898 | 211.249 | 574.959 |
| 147160 | SALINA AP | SALI | 38.817 | -97.667 | 145.454 | 544.915 |
| 148167 | TOPEKA BILLARD MUNI AP | TOPE | 39.069 | -95.639 | 319.802 | 577.785 |
| 148293 | UNIONTOWN | UNIO | 37.848 | -94.978 | 382.945 | 444.73 |
| 148830 | WICHITA | WICH | 37.650 | -97.433 | 168.277 | 415.757 |
| 165874 | MANSFIELD | MANS | 32.033 | -93.700 | 532.631 | -194.082 |
| 166244 | MINDEN | MIND | 32.600 | -93.300 | 566.346 | -128.864 |
| 166582 | NATCHITOCHES | NATC | 31.767 | -93.100 | 591.063 | -220.21 |
| 167738 | RED RIVER RSRCH STN | RED | 32.417 | -93.633 | 536.38 | -151.129 |
| 168440 | SHREVEPORT, LA | SHRE | 32.467 | -94.317 | 472.014 | -149.154 |
| 230204 | APPLETON CITY | APPL | 38.184 | -94.026 | 464.144 | 486.148 |
| 230789 | BOLIVAR 1 NE | BOLI | 37.617 | -93.391 | 523.377 | 426.582 |
| 231383 | CASSVILLE RANGER STN | CASS | 36.673 | -93.858 | 488.393 | 319.564 |
| 231791 | COLUMBIA REGIONAL AP | COLU | 38.817 | -92.218 | 616.384 | 566.475 |
| 232302 | DORA | DORA | 36.780 | -92.233 | 631.838 | 340.862 |
| 234315 | JOPLIN REGIONAL AP | JOPL | 37.147 | -94.502 | 428.471 | 369.008 |
| 234358 | KANSAS CITY AP | KANS | 39.300 | -94.717 | 397.998 | 606.872 |
| 234544 | KIRKSVILLE | KIRK | 40.200 | -92.567 | 575.475 | 717.609 |
| 234825 | LEBANON 2 W | LEBA | 37.685 | -92.694 | 584.043 | 438.162 |
| 235834 | MOUNTAIN GROVE 2 N | MOUN | 37.153 | -92.264 | 626.06 | 381.947 |
| 235987 | NEVADA WATER PLANT | NEVA | 37.839 | -94.373 | 435.885 | 446.376 |
| 237976 | SPRINGFIELD REG AP | SPRI | 37.240 | -93.390 | 526.086 | 384.835 |
| 238252 | TABLE ROCK DAM | TABL | 36.597 | -93.308 | 537.808 | 314.127 |
| 238466 | TRUMAN DAM & RESERVIOR | TRUM | 38.258 | -93.399 | 518.297 | 497.601 |
| 340179 | ALTUS IRIG RES STN | ALTU | 34.583 | -99.333 | 1.342 | 73.726 |
| 340215 | AMES | AMES | 36.250 | -98.183 | 104.257 | 259.348 |
| 340292 | ARDMORE | ARDM | 34.167 | -97.133 | 203.499 | 29.797 |

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 340670 | BENGAL | BENG | 34.850 | -95.083 | 388.412 | 111.938 |
| 341437 | CANEY | CANE | 34.233 | -96.217 | 287.462 | 39.536 |
| 341544 | CARTER TOWER | CART | 34.267 | -94.783 | 418.786 | 48.493 |
| 341684 | CHANDLER 1 | CHAN | 35.700 | -96.883 | 222.108 | 200.524 |
| 341750 | CHICKASHA EXP STN | CHIC | 35.050 | -97.917 | 130.07 | 126.502 |
| 342334 | CUSTER CITY | CUST | 35.650 | -98.833 | 46.415 | 192.255 |
| 342654 | DUNCAN AIRPORT | DUNC | 34.483 | -97.967 | 126.429 | 63.529 |
| 342849 | ELK CITY | ELK | 35.383 | -99.400 | -4.705 | 162.536 |
| 343281 | FORT COBB | FORT | 35.100 | -98.433 | 83.068 | 131.48 |
| 343497 | GEARY | GEAR | 35.633 | -98.317 | 93.029 | 190.78 |
| 344052 | HENNEPIN 5 N | HENN | 34.567 | -97.350 | 182.671 | 73.771 |
| 344202 | HOBART | HOBA | 35.033 | -99.083 | 24.058 | 123.718 |
| 344865 | KINGSTON | KING | 34.000 | -96.733 | 240.748 | 12.214 |
| 344975 | LAKE EUFAULA | LAKE | 35.283 | -95.433 | 354.598 | 158.646 |
| 345108 | LEHIGH | LEHI | 34.467 | -96.217 | 286.619 | 65.434 |
| 345463 | MACKIE 4 NNW | MACK | 35.750 | -99.833 | -43.712 | 203.34 |
| 345589 | MARSHALL | MARS | 36.150 | -97.617 | 155.133 | 249.015 |
| 345664 | MCALESTER MUNI AP | MCAL | 34.883 | -95.783 | 324.554 | 113.043 |
| 346130 | MUSKOGEE | MUSK | 35.767 | -95.333 | 361.415 | 212.616 |
| 346620 | OKARCHE | OKAR | 35.717 | -97.983 | 122.963 | 200.402 |
| 346638 | OKEMAH | OKEM | 35.433 | -96.300 | 275.597 | 172.448 |
| 346661 | OKLAHOMA CITY, OK | OKLA | 35.383 | -97.600 | 158.171 | 163.971 |
| 347196 | PONCA CITY | PONC | 36.717 | -97.100 | 199.951 | 312.875 |
| 347705 | ROFF 2 WNW | ROFF | 34.633 | -96.883 | 225.139 | 82.16 |
| 348992 | TULSA INTL AIRPORT | TULS | 36.198 | -95.888 | 309.803 | 258.552 |
| 349023 | TUSKAHOMA | TUSK | 34.633 | -95.283 | 371.223 | 87.116 |
| 349629 | WICHITA MTN WL REF | WICH | 34.733 | -98.717 | 57.604 | 90.569 |
| 349724 | WISTER | WIST | 34.950 | -94.700 | 422.763 | 124.642 |
| 349748 | WOLF 4 N | WOLF | 35.133 | -96.667 | 243.38 | 138.175 |
| 410016 | ABILENE MUN, TX | ABIL | 32.417 | -99.683 | -31.492 | -167 |
| 410926 | BONITA 4 NW | BONI | 33.833 | -97.633 | 158.221 | -8.161 |
| 411246 | BURLESON | BURL | 32.550 | -97.317 | 190.447 | -150.213 |
| 411698 | CHILDRESS MUNI AP | CHIL | 34.433 | -100.283 | -85.662 | 57.486 |
| 411773 | CLARKSVILLE 1 W | CLAR | 33.617 | -95.017 | 400.641 | -24.627 |
| 411921 | COMMERCE | COMM | 33.200 | -95.933 | 317.534 | -74.315 |
| 412086 | CRANFILLS GAP | CRAN | 31.767 | -97.833 | 143.384 | -238.27 |
| 412096 | CRESSON | CRES | 32.533 | -97.617 | 162.357 | -152.616 |
| 412131 | CROSS PLAINS 2 | CROS | 32.133 | -99.167 | 17.09 | -198.565 |
| 412242 | DALLAS-FORT WORTH/FORT. TX. | DALL | 32.900 | -97.017 | 217.625 | -110.663 |
| 412244 | DALLAS LOVE FIELD | DALL | 32.850 | -96.850 | 233.324 | -115.831 |
| 412404 | DENTON 2 SE | DENT | 33.200 | -97.100 | 209.069 | -77.506 |
| 412715 | EASTLAND | EAST | 32.400 | -98.817 | 49.911 | -168.771 |

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 413133 | FERRIS | FERR | 32.517 | -96.667 | 251.477 | -152.428 |
| 413285 | FORT WORTH WSFO | FORT | 32.833 | -97.300 | 191.339 | -118.676 |
| 413415 | GAINESVILLE | GAIN | 33.633 | -97.133 | 204.862 | -29.433 |
| 413546 | GILMER 2 W | GILM | 32.733 | -94.983 | 408.173 | -122.577 |
| 413642 | GORDONVILLE | GORD | 33.800 | -96.850 | 230.585 | -10.281 |
| 413771 | GROESBECK 2 | GROE | 31.533 | -96.533 | 267.178 | -261.477 |
| 414137 | HICO | HICO | 31.983 | -98.033 | 124.123 | -214.429 |
| 414257 | HONEY GROVE | HONE | 33.583 | -95.900 | 319.106 | -31.63 |
| 414520 | JACKSBORO 1 NNE | JACK | 33.233 | -98.150 | 111.378 | -75.549 |
| 414866 | KOPPERL | KOPP | 32.133 | -97.483 | 175.721 | -196.88 |
| 414972 | LAKE BRIDGEPORT DAM | LAKE | 33.217 | -97.833 | 140.846 | -76.986 |
| 415348 | LONGVIEW TX. | LONG | 32.350 | -94.650 | 441.401 | -163.699 |
| 415463 | MABANK 4 SW | MABA | 32.350 | -96.117 | 303.664 | -169.375 |
| 415957 | MINERAL WELLS 1 SSW | MINE | 32.783 | -98.117 | 115.117 | -125.535 |
| 415996 | MOLINE | MOLI | 31.400 | -98.317 | 98.07 | -279.711 |
| 416108 | MOUNT PLEASANT | MOUN | 33.167 | -95.000 | 404.44 | -74.517 |
| 416177 | NACOGDOCHES | NACO | 31.617 | -94.650 | 445.383 | -245.232 |
| 416210 | NAVARRO MILLS DAM | NAVA | 31.950 | -96.700 | 250.085 | -215.548 |
| 416270 | NEW BOSTON | NEW | 33.450 | -94.417 | 457.042 | -40.453 |
| 416335 | NEW SUMMERFIELD 2 W | NEW | 31.983 | -95.133 | 397.806 | -206.567 |
| 416757 | PALESTINE 2 NE | PALE | 31.783 | -95.600 | 354.65 | -230.638 |
| 416834 | PAT MAYSE DAM | PAT | 33.867 | -95.517 | 353.313 | 1.165 |
| 417066 | PITTSBURG 5 S | PITT | 32.933 | -94.933 | 411.826 | -100.148 |
| 417300 | PROCTOR RESERVOIR | PROC | 31.967 | -98.500 | 80.081 | -216.779 |
| 417499 | RED SPRINGS 2 ESE | RED | 33.600 | -99.383 | -3.269 | -35.493 |
| 417556 | RENO | RENO | 32.950 | -97.567 | 166.188 | -106.202 |
| 418047 | SANTA ANNA | SANT | 31.750 | -99.333 | 1.39 | -241.254 |
| 418583 | STAMFORD 1 | STAM | 32.933 | -99.800 | -42.179 | -109.493 |
| 418623 | STEPHENVILLE 1 N | STEP | 32.250 | -98.200 | 108.034 | -184.954 |
| 418743 | SULPHUR SPRINGS | SULP | 33.150 | -95.633 | 345.632 | -78.835 |
| 418778 | SWAN | SWAN | 32.450 | -95.417 | 368.959 | -155.811 |
| 419163 | TRUSCOTT | TRUS | 33.750 | -99.867 | -47.911 | -18.699 |
| 419419 | WACOMADISON-COOPER TX. | WACO | 31.617 | -97.233 | 200.54 | -253.899 |
| 419532 | WEATHERFORD | WEAT | 32.750 | -97.767 | 147.896 | -128.764 |
| 419565 | WELLINGTON | WELL | 34.833 | -100.217 | -79.156 | 101.839 |
| 419715 | WHITNEY DAM | WHIT | 31.850 | -97.367 | 187.363 | -228.192 |
| 419729 | WICHITA FALLS/SHEPS AFB TX | WICH | 33.983 | -98.500 | 78.106 | 7.437 |
| 419817 | WINCHELL | WINC | 31.467 | -99.167 | 17.23 | -272.793 |
| 419893 | WOODSON | WOOD | 33.017 | -99.050 | 27.781 | -100.284 |
| 419916 | WRIGHT PATMAN | WRIG | 33.300 | -94.167 | 481.088 | -55.882 |
| 118179 | SPRINGFIELD | SPRI | 39.850 | -89.680 | 823.683 | 699.815 |
| 114442 | JACKSONVILLE | JACK | 39.730 | -90.200 | 780.783 | 682.207 |

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 116837 | PITTSFIELD | PITT | 39.610 | -90.800 | 730.895 | 664.216 |
| 231640 | CLARKSVILLE L&D | CLAR | 39.360 | -90.900 | 724.802 | 635.788 |
| 113666 | GREENFIELD | GREE | 39.350 | -90.210 | 783.935 | 640.088 |
| 111284 | CARLINVILLE | CARL | 39.280 | -89.880 | 812.919 | 635.084 |
| 115841 | MORRISONVILLE | MORR | 39.410 | -89.460 | 847.375 | 653.077 |
| 111290 | CARLYLE RESERVOIR | CARL | 38.630 | -89.360 | 864.887 | 567.788 |
| 118147 | SPARTA | SPAR | 38.110 | -89.710 | 840.454 | 507.252 |
| 115983 | MURPHYSBORO | MURP | 37.760 | -89.360 | 874.891 | 471.721 |
| 233601 | HANNIBAL WATER WORKS | HANN | 39.710 | -91.360 | 682.205 | 671.178 |
| 231600 | CLARENCE CANNON DAM | CLAR | 39.530 | -91.630 | 660.799 | 649.357 |
| 235050 | LONG BRANCH RESERVOIR | LONG | 39.750 | -92.510 | 583.855 | 668.049 |
| 235671 | MOBERLY | MOBE | 39.400 | -92.430 | 593.467 | 629.742 |
| 236012 | NEW FRANKLIN | NEW | 39.010 | -92.750 | 569.027 | 584.59 |
| 233079 | FULTON | FULT | 38.850 | -91.930 | 640.981 | 572.019 |
| 231283 | CAP AU GRIS | CAP | 39.000 | -90.680 | 747.223 | 597.635 |
| 238746 | WASHINGTON | WASH | 38.550 | -90.980 | 725.766 | 545.56 |
| 237300 | ROSEBUD | ROSE | 38.450 | -91.380 | 692.073 | 531.55 |
| 237263 | ROLLA UNIV OF MO | ROLL | 37.950 | -91.780 | 661.764 | 473.409 |
| 238620 | VIENNA | VIEN | 38.200 | -91.980 | 642.188 | 499.724 |
| 238043 | STEELVILLE | STEE | 38.000 | -91.360 | 697.947 | 481.907 |
| 236826 | POTOSI | POTO | 37.960 | -90.760 | 750.633 | 481.998 |
| 238609 | VIBURNUM | VIBU | 37.710 | -91.130 | 720.74 | 451.526 |
| 237506 | SALEM | SALE | 37.550 | -91.880 | 656.478 | 428.461 |
| 230088 | ALLEY SPRINGS | ALLE | 37.150 | -91.450 | 697.833 | 387.234 |
| 231674 | CLEARWATER DAM | CLEA | 37.130 | -90.760 | 758.841 | 390.244 |
| 232809 | FARMINGTON | FARM | 37.800 | -90.410 | 782.785 | 467.099 |
| 230022 | ADVANCE | ADVA | 37.100 | -89.900 | 834.924 | 394.048 |
| 238700 | WAPPAPELLO DAM | WAPP | 36.930 | -90.280 | 803.219 | 372.036 |
| 238880 | WEST PLAINS | WEST | 36.750 | -91.830 | 667.791 | 340.292 |
| 232302 | DORA | DORA | 36.780 | -92.230 | 632.081 | 340.911 |
| 235207 | MALDEN MUNICIPAL | MALD | 36.610 | -89.980 | 833.16 | 339.238 |
| 233999 | HORNERSVILLE | HORN | 36.050 | -90.110 | 827.589 | 276.263 |
| 220237 | ARKABUTLA DAM, MS | ARKA | 34.450 | -90.080 | 847.34 | 99.742 |
| 221314 | CALHOUN CITY 2 NW | CALH | 33.520 | -89.210 | 937.459 | 5.027 |
| 221707 | CLARKSDALE | CLAR | 34.120 | -90.340 | 827.064 | 60.998 |
| 221743 | CLEVELAND 3 N | CLEV | 33.480 | -90.430 | 825.402 | -10.568 |
| 223650 | GRENADA DAM | GREN | 33.480 | -89.460 | 914.88 | -1.8 |
| 224001 | HICKORY FLAT | HICK | 34.370 | -89.110 | 936.648 | 99.892 |
| 224173 | HOLLY SPRINGS 4 N | HOLL | 34.490 | -89.260 | 921.582 | 111.695 |
| 226084 | MOUNT PLEASANT 4 SW | MOUN | 34.540 | -89.330 | 914.634 | 116.549 |
| 227820 | SAREPTA 1 NNE | SARE | 34.070 | -89.180 | 933.781 | 66.081 |
| 229079 | UNIVERSITY, MS | UNIV | 34.230 | -89.320 | 919.123 | 82.406 |

| Station ID | Name | ID | Latitude | Longitude | X (km) | Y (km) |
|---|---|---|---|---|---|---|
| 400876 | BOLIVAR WATERWORKS, TN | BOLI | 35.160 | -88.590 | 974.247 | 192.241 |
| 401150 | BROWNSVILLE SEWAGE P | BROW | 35.350 | -89.160 | 920.598 | 207.596 |
| 403697 | GREENFIELD | GREE | 36.100 | -88.470 | 973.304 | 297.122 |
| 404556 | JACKSON MCKELLAR-SIP | JACK | 35.360 | -88.550 | 975.369 | 214.706 |
| 404561 | JACKSON EXP STA | JACK | 35.370 | -88.500 | 979.742 | 216.317 |
| 405720 | MASON | MASO | 35.240 | -89.320 | 907.463 | 193.934 |
| 405954 | MEMPHIS INTL ARPT | MEMP | 35.030 | -90.000 | 848.388 | 164.54 |
| 405956 | MEMPHIS WSFO | MEMP | 35.080 | -89.480 | 894.852 | 174.771 |
| 406358 | MUNFORD | MUNF | 35.270 | -89.490 | 891.793 | 195.658 |
| 406750 | OAK RIDGE | OAK | 36.000 | -84.150 | 1358.823 | 338.461 |
| 408065 | SAMBURG WILDLIFE REF | SAMB | 36.270 | -89.190 | 907.143 | 308.843 |
| 409219 | UNION CITY, TN | UNIO | 36.240 | -89.020 | 922.623 | 307.148 |
| 30064 | ALICIA, AR | ALIC | 35.540 | -91.050 | 748.472 | 212.202 |
| 30458 | BATESVILLE LIVESTOCK | BATE | 35.500 | -91.460 | 711.939 | 204.668 |
| 30530 | BEEBE | BEEB | 35.040 | -91.540 | 708.871 | 153.189 |
| 30936 | BRINKLEY | BRIN | 34.530 | -91.110 | 752.656 | 100.029 |
| 31632 | CORNING | CORN | 36.260 | -90.350 | 803.976 | 297.429 |
| 32148 | DUMAS | DUMA | 33.530 | -91.290 | 745.537 | -12.05 |
| 32978 | GREERS FERRY DAM | GREE | 35.310 | -92.000 | 664.907 | 179.784 |
| 33132 | HARDY | HARD | 36.170 | -91.280 | 721.923 | 280.109 |
| 34900 | MONTICELLO 3 SW | MONT | 33.360 | -91.480 | 729.54 | -32.333 |
| 35754 | PINE BLUFF | PINE | 34.140 | -92.010 | 673.896 | 50.191 |
| 36920 | STUTTGART 9 ESE | STUT | 34.280 | -91.250 | 742.228 | 71.28 |
| 38052 | WYNNE, AR | WYNN | 35.150 | -90.480 | 803.727 | 173.682 |

# APPENDIX C

## DETAILED EMISSION CALCULATIONS

Table C-1. Model Inputs Summary

| Source Name | Base Elevation | Latitude NAD83 | Longitude NAD83 | Stack Ht. | GEP Stack Height | Stack Diameter | Exit Velocity | Gas Temperature |
|---|---|---|---|---|---|---|---|---|
| | ft | dec. deg. | dec. deg. | ft | ft | ft | ft/sec | °F |
| La Cygne - Unit 1 | 850 | 38.349 | -94.646 | 700 | 591.2 | 23.0 | 92.7 | 127 |
| La Cygne - Unit 2 | 850 | 38.348 | -94.646 | 700 | 597.8 | 24.0 | 100.8 | 281 |

| BART-Eligible Source Name | Highest 24 hr Actual Emission Rate¶ 2002-2004 ton/24 hr | | | Input to CALPUFF Hourly Mass Emission Rate lb/hr | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | $PM_{10}$ | $SO_2$ | $NO_X$ | $PM_{10}$ | $SO_4$ | $PM_C$ | $PM_f$ | SOA | EC |
| La Cygne - Unit 1 | 73.81 | 139.07 | 0.65 | 6,151.15 | 11,589.52 | 53.79 | 34.37 | 4.92 | 5.68 | 8.59 | 0.22 |
| La Cygne - Unit 2 | 99.79 | 42.52 | 1.14 | 8,316.15 | 3,543.47 | 94.92 | 28.12 | 33.20 | 25.58 | 7.03 | 0.98 |

¶The Highest 24-hr Actual Mass Emission Rates of $SO_2$ and $NO_X$ are determined from actual monitored data from 2002-2004. The Highest 24-hr Actual Mass Emission Rate of $PM_{10}$ is calculated based on actual fuel usage data (the maximum daily heat input from 2002-2004, the minimum annual average fuel heat content from 2002-2004, the maximum annual average ash content from 2002 to 2004, and the maximum annual average sulfur content from 2002-2004) and AP-42 emission factors (see Table C-2).

Table C-2.
PM10 Emissions

**24-Hr Fuel Usage**

| | Maximum 24-Hr Coal Usage (ton/24hr) | Maximum 24-Hr Heat Input (MMBtu/24hr) |
|---|---|---|
| La Cygne 1 | 12,806 | 223,488 |
| La Cygne 2 | 11,739 | 198,911 |

The maximum daily coal usage is calculated by dividing the maximum daily heat input from 2002-2004 by the minimum of the annual average heat contents from 2002-2004.

The maximum daily heat input is the maximum daily heat input from the years 2002-2004.

**PM10 Filterable and Condensable Emission Factors**

| | PM10 Filterable Emission Factor* | Emission Factor Units | Emission Factor Source | PM10 Condensible Emission Factor** | Units | Source | Sulfur Content§ (%) | Ash Content¥ (%) | Control Efficiency Filterable | Control Efficiency Condensable |
|---|---|---|---|---|---|---|---|---|---|---|
| La Cygne 1 | 2.17 | lb/ton | AP-42 Table 1.1-4 | 0.02 | lb/MMBtu | AP-42 Table 1.1-5 | 1.21 | 8.35 | 96% | 96% |
| La Cygne 2 | 12.63 | lb/ton | AP-42 Table 1.1-4 | 0.004 | lb/MMBtu | AP-42 Table 1.1-5 | 0.34 | 5.49 | 99% | 0% |

*PM10 filterable emission factors are for "Cyclone furnace" boiler (La Cygne 1) and "PC-fired, dry bottom, wall-fired" boiler" (La Cygne 2).

**PM10 condensable emission factor for La Cygne 1 is for PC boiler with FGD control; the factor for La Cygne 2 is for PC boiler without FGD control.

§The coal sulfur content is the maximum of the annual average sulfur contents from 2002-2004.

¥The coal ash content is the maximum of the annual average ash contents from 2002-2004.

**24-Hr Emissions**

| | PM10 Filterable 24-Hr Emissions (Uncontrolled) (lb/24-hr) | PM10 Condensable 24-Hr Emissions (Uncontrolled) (lb/24-hr) | Total PM10 (Uncontrolled) (lb/24-hr) | PM10 Filterable Emissions (Controlled) (lb/24-hr) | PM10 Condensable Emissions (Controlled) (lb/24-hr) | Total PM10 (Controlled) (lb/24-hr) |
|---|---|---|---|---|---|---|
| La Cygne 1 | 27,802 | 4,470 | 32,271 | 1,112 | 179 | 1,291 |
| La Cygne 2 | 148,232 | 796 | 149,028 | 1,482 | 796 | 2,278 |

**Hourly Emissions (Based on 24-hr emissions divided by 24hrs)**

| | PM10 Filterable 24-Hr Emissions (Uncontrolled) (lb/hr) | PM10 Condensable 24-Hr Emissions (Uncontrolled) (lb/hr) | Total PM10 (Uncontrolled) (lb/hr) | PM10 Filterable Emissions (Controlled) (lb/hr) | PM10 Condensable Emissions (Controlled) (lb/hr) | Total PM10 (Controlled) (lb/hr) |
|---|---|---|---|---|---|---|
| La Cygne 1 | 1,158 | 186 | 1,345 | 46 | 7 | 54 |
| La Cygne 2 | 6,176 | 33 | 6,209 | 62 | 33.15 | 95 |

Table C-3.
La Cygne Unit 1 PM10 Speciation

**Controlled PM10 Speciation from AP-42 Tables 1.1-5 & 1.1-8**
**Cyclone Furnace w FGD + ESP for Emissions control**

assumes heating value of **8,794** Btu/lb and a sulfur content of **1.03** % and an ash content of **8.05** % and a heat in **9,312** mmBtu/hr and f(RH) = **1**

| | Controlled PM10 Emissions (**Bold** values from Table 1.1-5.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (lb/mmBtu) | Filterable (lb/mmBtu) | Coarse (lb/mmBtu) | Ext. Coef. | Fine (lb/mmBtu) | Fine Soil (lb/ton) | Ext. Coef. | Fine EC (lb/mmBtu) | Ext. Coef. | Condensible (lb/mmBtu) | CPM IOR (lb/mmBtu) | Particle Type | Particle Ext.Coef. | CPM OR (lb/mmBtu) | Particle Type | Particle Ext.Coef. |
| Cyclone | 0.0250 | 0.0050 | 0.0023 | 0.6 | 0.0027 | 0.00265 | 1 | 0.00010 | 10 | **0.020** | **0.016** | SO4 | 3*f(RH) | **0.004** | SOA | 4 |

| | Controlled PM10 Emissions (**Bold** Values from Table 1.1-8.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (lb/ton) | Filterable (lb/ton) | Coarse (lb/ton) | Ext. Coef. | Fine (lb/ton) | Fine Soil (lb/ton) | Ext. Coef. | Fine EC (lb/ton) | Ext. Coef. | Condensible (lb/ton) | CPM IOR (lb/ton) | Particle Type | Particle Ext.Coef. | CPM OR (lb/ton) | Particle Type | Particle Ext.Coef. |
| Cyclone | 0.440 | **0.089** | 0.040 | 0.6 | **0.048** | 0.0465 | 1 | 0.0018 | 10 | 0.352 | 0.281 | SO4 | 3*f(RH) | 0.070 | SOA | 4 |

| | Controlled PM10 Emissions | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (% of Total) | Filterable (% of Total) | Coarse (% of Total) | Ext. Coef. | Fine (% of Total) | Fine Soil (% of Total) | Ext. Coef. | Fine EC (% of Total) | Ext. Coef. | Condensible (% of Total) | CPM IOR (% of Total) | Particle Type | Particle Ext.Coef. | CPM OR (% of Total) | Particle Type | Particle Ext.Coef. |
| Cyclone | 100% | 20.1% | 9.1% | 0.6 | 11.0% | 10.6% | 1 | 0.4% | 10 | 79.9% | 63.9% | SO4 | 3*f(RH) | 16.0% | SOA | 4 |

**If you are given Total PM10 emissions in lb/hr:**

| | Controlled PM10 Emissions (**Bold** Value is **Input** by user.) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (lb/hr) | Filterable (lb/hr) | Coarse (lb/hr) | Ext. Coef. | Fine (lb/hr) | Fine Soil (lb/hr) | Ext. Coef. | Fine EC (lb/hr) | Ext. Coef. | Condensible (lb/hr) | CPM IOR (lb/hr) | Particle Type | Particle Ext.Coef. | CPM OR (lb/hr) | Particle Type | Particle Ext.Coef. | |
| Cyclone | **53.8** | 10.82 | 4.92 | 0.6 | 5.90 | 5.68 | 1 | 0.22 | 10 | 43.0 | 34.4 | SO4 | 3 | 8.6 | SOA | 4 | |
| | | Weighted Extinction | | 3.0 | | | 5.7 | | 2.2 | | | | 103.1 | | | 34.4 | 2.8 |

| | | | | |
|---|---|---|---|---|
| Coarse | 9.1% | | Coarse | 4.9 |
| Fine Soil | 10.6% | | Fine Soil | 5.7 |
| Fine EC | 0.4% | | Fine EC | 0.2 |
| CPM IOR | 63.9% | | CPM IOR | 34.4 |
| CPM OR | 16.0% | | CPM OR | 8.6 |
| | 100.0% | | | 53.8 |

Table C-4.
La Cygne Unit 2 PM10 Speciation

**Controlled PM10 Speciation from AP-42 Tables 1.1-5 & 1.1-6**
**Dry Bottom Boiler burning Pulverized Coal using only ESP for Emissions control**

assumes heating value of **8596** Btu/lb and a sulfur content of **0.33** % and an ash content of **5.41** % and a heat input c **8,288** mmBtu/hr and f(RH) = **1**

| | Controlled PM10 Emissions (**Bold** values from Table 1.1-5.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (lb/mmBtu) | Filterable (lb/mmBtu) | Coarse (lb/mmBtu) | Ext. Coef. | Fine (lb/mmBtu) | Fine Soil (lb/ton) | Ext. Coef. | Fine EC (lb/mmBtu) | Ext. Coef. | Condensible (lb/mmBtu) | CPM IOR (lb/mmBtu) | Particle Type | Particle Ext.Coef. | CPM OR (lb/mmBtu) | Particle Type | Particle Ext.Coef. |
| PC-DB | 0.0270 | 0.0170 | 0.0094 | 0.6 | 0.0076 | 0.0073 | 1 | 0.0003 | 10 | **0.010** | **0.008** | SO4 | 3*f(RH) | **0.002** | SOA | 4 |

| | Controlled PM10 Emissions (**Bold** Values from Table 1.1-6.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (lb/ton) | Filterable (lb/ton) | Coarse (lb/ton) | Ext. Coef. | Fine (lb/ton) | Fine Soil (lb/ton) | Ext. Coef. | Fine EC (lb/ton) | Ext. Coef. | Condensible (lb/ton) | CPM IOR (lb/ton) | Particle Type | Particle Ext.Coef. | CPM OR (lb/ton) | Particle Type | Particle Ext.Coef. |
| PC-DB | 0.464 | **0.292** | 0.162 | 0.6 | **0.130** | 0.125 | 1 | 0.005 | 10 | 0.172 | 0.138 | SO4 | 3*f(RH) | 0.034 | SOA | 4 |

| | Controlled PM10 Emissions | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (% of Total) | Filterable (% of Total) | Coarse (% of Total) | Ext. Coef. | Fine (% of Total) | Fine Soil (% of Total) | Ext. Coef. | Fine EC (% of Total) | Ext. Coef. | Condensible (% of Total) | CPM IOR (% of Total) | Particle Type | Particle Ext.Coef. | CPM OR (% of Total) | Particle Type | Particle Ext.Coef. |
| PC-DB | 100% | 63.0% | 35.0% | 0.6 | 28.0% | 26.9% | 1 | 1.0% | 10 | 37.0% | 29.6% | SO4 | 3*f(RH) | 7.4% | SOA | 4 |

**If you are given Total PM10 emissions in lb/hr:**

| | Controlled PM10 Emissions (**Bold** Value is **Input** by user.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler Type | Total PM10 (lb/hr) | Filterable (lb/hr) | Coarse (lb/hr) | Ext. Coef. | Fine (lb/hr) | Fine Soil (lb/hr) | Ext. Coef. | Fine EC (lb/hr) | Ext. Coef. | Condensible (lb/hr) | CPM IOR (lb/hr) | Particle Type | Particle Ext.Coef. | CPM OR (lb/hr) | Particle Type | Particle Ext.Coef. |
| PC-DB | **94.9** | 59.8 | 33.2 | 0.6 | 26.6 | 25.6 | 1 | 1.0 | 10 | 35.2 | 28.1 | SO4 | 3 | 7.0 | SOA | 4 |
| | | Weighted Extinction | | 19.9 | | | 25.6 | | 9.8 | | | | 84.4 | | | 28.1 |

1.8

| | | | |
|---|---|---|---|
| Coarse | 35.0% | Coarse | 33.2 |
| Fine Soil | 26.9% | Fine Soil | 25.6 |
| Fine EC | 1.0% | Fine EC | 1.0 |
| CPM IOR | 29.6% | CPM IOR | 28.1 |
| CPM OR | 7.4% | CPM OR | 7.0 |
| | 100.0% | | 94.9 |

## RECEPTOR DATA

| Receptor | Latitude (deg) | Longitude (deg) | Elevation (m) |
|---|---|---|---|
| 1 | 36.654 | -92.946 | 274 |
| 2 | 36.654 | -92.938 | 299 |
| 3 | 36.654 | -92.929 | 328 |
| 4 | 36.654 | -92.921 | 365 |
| 5 | 36.663 | -92.963 | 250 |
| 6 | 36.663 | -92.954 | 278 |
| 7 | 36.663 | -92.946 | 335 |
| 8 | 36.663 | -92.938 | 307 |
| 9 | 36.663 | -92.929 | 345 |
| 10 | 36.671 | -92.971 | 261 |
| 11 | 36.671 | -92.963 | 271 |
| 12 | 36.671 | -92.954 | 274 |
| 13 | 36.671 | -92.946 | 331 |
| 14 | 36.671 | -92.938 | 327 |
| 15 | 36.671 | -92.929 | 304 |
| 16 | 36.671 | -92.921 | 335 |
| 17 | 36.671 | -92.913 | 312 |
| 18 | 36.671 | -92.904 | 340 |
| 19 | 36.671 | -92.896 | 361 |
| 20 | 36.671 | -92.888 | 382 |
| 21 | 36.679 | -92.971 | 274 |
| 22 | 36.679 | -92.963 | 274 |
| 23 | 36.679 | -92.954 | 335 |
| 24 | 36.679 | -92.946 | 294 |
| 25 | 36.679 | -92.938 | 304 |
| 26 | 36.679 | -92.929 | 279 |
| 27 | 36.679 | -92.921 | 304 |
| 28 | 36.679 | -92.913 | 318 |
| 29 | 36.679 | -92.904 | 335 |
| 30 | 36.679 | -92.896 | 347 |
| 31 | 36.679 | -92.888 | 340 |
| 32 | 36.688 | -92.954 | 247 |
| 33 | 36.688 | -92.946 | 271 |
| 34 | 36.688 | -92.938 | 275 |
| 35 | 36.688 | -92.929 | 274 |
| 36 | 36.688 | -92.921 | 277 |
| 37 | 36.688 | -92.913 | 304 |
| 38 | 36.688 | -92.904 | 330 |
| 39 | 36.688 | -92.896 | 357 |
| 40 | 36.688 | -92.888 | 384 |
| 41 | 36.688 | -92.879 | 372 |
| 42 | 36.696 | -92.979 | 274 |
| 43 | 36.696 | -92.971 | 293 |
| 44 | 36.696 | -92.963 | 272 |
| 45 | 36.696 | -92.954 | 271 |
| 46 | 36.696 | -92.946 | 274 |
| 47 | 36.696 | -92.938 | 327 |

| Receptor | Latitude (deg) | Longitude (deg) | Elevation (m) |
|---|---|---|---|
| 48 | 36.696 | -92.929 | 316 |
| 49 | 36.696 | -92.921 | 304 |
| 50 | 36.696 | -92.913 | 354 |
| 51 | 36.696 | -92.904 | 346 |
| 52 | 36.696 | -92.896 | 335 |
| 53 | 36.696 | -92.888 | 344 |
| 54 | 36.696 | -92.879 | 364 |
| 55 | 36.704 | -92.971 | 243 |
| 56 | 36.704 | -92.963 | 335 |
| 57 | 36.704 | -92.954 | 324 |
| 58 | 36.704 | -92.946 | 335 |
| 59 | 36.704 | -92.938 | 341 |
| 60 | 36.704 | -92.929 | 333 |
| 61 | 36.704 | -92.921 | 306 |
| 62 | 36.704 | -92.913 | 304 |
| 63 | 36.704 | -92.904 | 365 |
| 64 | 36.704 | -92.896 | 304 |
| 65 | 36.704 | -92.888 | 309 |
| 66 | 36.704 | -92.879 | 307 |
| 67 | 36.713 | -92.971 | 270 |
| 68 | 36.713 | -92.963 | 274 |
| 69 | 36.713 | -92.954 | 301 |
| 70 | 36.713 | -92.946 | 274 |
| 71 | 36.713 | -92.938 | 274 |
| 72 | 36.713 | -92.929 | 312 |
| 73 | 36.713 | -92.921 | 274 |
| 74 | 36.713 | -92.913 | 322 |
| 75 | 36.713 | -92.904 | 304 |
| 76 | 36.713 | -92.896 | 275 |
| 77 | 36.713 | -92.888 | 304 |
| 78 | 36.713 | -92.879 | 290 |
| 79 | 36.721 | -92.913 | 249 |
| 80 | 36.721 | -92.904 | 274 |
| 81 | 34.704 | -98.754 | 454 |
| 82 | 34.704 | -98.746 | 486 |
| 83 | 34.704 | -98.738 | 487 |
| 84 | 34.704 | -98.729 | 478 |
| 85 | 34.704 | -98.721 | 518 |
| 86 | 34.704 | -98.713 | 518 |
| 87 | 34.713 | -98.771 | 510 |
| 88 | 34.713 | -98.763 | 493 |
| 89 | 34.713 | -98.754 | 488 |
| 90 | 34.713 | -98.746 | 615 |
| 91 | 34.713 | -98.738 | 522 |
| 92 | 34.713 | -98.729 | 494 |
| 93 | 34.713 | -98.721 | 609 |
| 94 | 34.713 | -98.713 | 518 |
| 95 | 34.721 | -98.779 | 487 |
| 96 | 34.721 | -98.771 | 518 |
| 97 | 34.721 | -98.763 | 609 |
| 98 | 34.721 | -98.754 | 554 |
| 99 | 34.721 | -98.746 | 578 |
| 100 | 34.721 | -98.738 | 557 |
| 101 | 34.721 | -98.729 | 571 |

| Receptor | Latitude (deg) | Longitude (deg) | Elevation (m) |
|---|---|---|---|
| 102 | 34.721 | -98.721 | 670 |
| 103 | 34.721 | -98.713 | 518 |
| 104 | 34.729 | -98.763 | 518 |
| 105 | 34.729 | -98.754 | 548 |
| 106 | 34.729 | -98.746 | 548 |
| 107 | 34.729 | -98.738 | 518 |
| 108 | 34.738 | -98.763 | 517 |
| 109 | 34.738 | -98.754 | 579 |
| 110 | 34.738 | -98.746 | 613 |
| 111 | 34.738 | -98.738 | 548 |
| 112 | 34.738 | -98.729 | 523 |
| 113 | 34.746 | -98.771 | 542 |
| 114 | 34.746 | -98.763 | 545 |
| 115 | 34.746 | -98.754 | 552 |
| 116 | 34.771 | -98.679 | 579 |
| 117 | 34.779 | -98.713 | 609 |
| 118 | 34.779 | -98.704 | 654 |
| 119 | 34.779 | -98.696 | 621 |
| 120 | 34.779 | -98.688 | 629 |
| 121 | 34.779 | -98.679 | 579 |
| 122 | 34.779 | -98.671 | 560 |
| 123 | 34.788 | -98.721 | 615 |
| 124 | 34.788 | -98.713 | 641 |
| 125 | 34.788 | -98.704 | 640 |
| 126 | 34.788 | -98.696 | 662 |
| 127 | 34.788 | -98.688 | 618 |
| 128 | 34.788 | -98.679 | 630 |
| 129 | 34.788 | -98.671 | 534 |
| 130 | 34.796 | -98.721 | 606 |
| 131 | 34.796 | -98.713 | 566 |
| 132 | 34.796 | -98.704 | 633 |
| 133 | 34.796 | -98.696 | 670 |
| 134 | 34.796 | -98.688 | 609 |
| 135 | 34.796 | -98.679 | 579 |
| 136 | 34.796 | -98.671 | 535 |
| 137 | 34.804 | -98.704 | 548 |
| 138 | 34.804 | -98.696 | 518 |
| 139 | 34.804 | -98.688 | 506 |
| 140 | 35.821 | -93.454 | 555 |
| 141 | 35.821 | -93.446 | 589 |
| 142 | 35.821 | -93.421 | 563 |
| 143 | 35.829 | -93.454 | 549 |
| 144 | 35.829 | -93.446 | 487 |
| 145 | 35.829 | -93.438 | 487 |
| 146 | 35.829 | -93.429 | 490 |
| 147 | 35.838 | -93.454 | 650 |
| 148 | 35.838 | -93.446 | 563 |
| 149 | 35.838 | -93.438 | 540 |
| 150 | 35.838 | -93.429 | 502 |
| 151 | 35.838 | -93.421 | 526 |
| 152 | 35.838 | -93.404 | 534 |
| 153 | 35.838 | -93.396 | 563 |
| 154 | 35.846 | -93.454 | 548 |
| 155 | 35.846 | -93.446 | 628 |

| Receptor | Latitude (deg) | Longitude (deg) | Elevation (m) |
|---|---|---|---|
| 156 | 35.846 | -93.438 | 623 |
| 157 | 35.846 | -93.429 | 579 |
| 158 | 35.846 | -93.421 | 469 |
| 159 | 35.846 | -93.413 | 457 |
| 160 | 35.846 | -93.404 | 573 |
| 161 | 35.846 | -93.396 | 605 |
| 162 | 35.846 | -93.388 | 588 |
| 163 | 35.854 | -93.454 | 608 |
| 164 | 35.854 | -93.446 | 660 |
| 165 | 35.854 | -93.438 | 598 |
| 166 | 35.854 | -93.429 | 599 |
| 167 | 35.854 | -93.421 | 639 |
| 168 | 35.854 | -93.413 | 457 |
| 169 | 35.854 | -93.404 | 568 |
| 170 | 35.863 | -93.454 | 730 |
| 171 | 35.863 | -93.446 | 681 |
| 172 | 35.863 | -93.438 | 640 |
| 173 | 35.863 | -93.429 | 625 |
| 174 | 35.863 | -93.421 | 426 |
| 175 | 35.863 | -93.413 | 555 |
| 176 | 35.863 | -93.404 | 612 |
| 177 | 35.871 | -93.463 | 667 |
| 178 | 35.871 | -93.454 | 580 |
| 179 | 35.871 | -93.446 | 656 |
| 180 | 35.871 | -93.438 | 640 |
| 181 | 35.871 | -93.429 | 487 |
| 182 | 35.871 | -93.421 | 457 |
| 183 | 35.871 | -93.413 | 654 |
| 184 | 35.871 | -93.404 | 548 |
| 185 | 35.871 | -93.396 | 622 |
| 186 | 35.871 | -93.388 | 683 |
| 187 | 35.879 | -93.463 | 579 |
| 188 | 35.879 | -93.454 | 554 |
| 189 | 35.879 | -93.446 | 609 |
| 190 | 35.879 | -93.438 | 622 |
| 191 | 35.879 | -93.429 | 427 |
| 192 | 35.879 | -93.421 | 555 |
| 193 | 35.879 | -93.413 | 502 |
| 194 | 35.879 | -93.404 | 639 |
| 195 | 35.879 | -93.396 | 580 |
| 196 | 35.879 | -93.388 | 639 |
| 197 | 35.888 | -93.446 | 548 |
| 198 | 35.888 | -93.438 | 548 |
| 199 | 35.888 | -93.429 | 438 |
| 200 | 35.888 | -93.421 | 579 |
| 201 | 35.888 | -93.404 | 620 |
| 202 | 35.896 | -93.429 | 579 |
| 203 | 35.896 | -93.421 | 426 |
| 204 | 35.896 | -93.413 | 611 |
| 205 | 35.904 | -93.446 | 604 |
| 206 | 35.904 | -93.438 | 548 |
| 207 | 35.904 | -93.429 | 488 |
| 208 | 35.904 | -93.421 | 402 |
| 209 | 35.904 | -93.413 | 579 |

| Receptor | Latitude (deg) | Longitude (deg) | Elevation (m) |
|---|---|---|---|
| 210 | 35.904 | -93.404 | 573 |
| 211 | 35.904 | -93.396 | 609 |
| 212 | 34.371 | -94.054 | 365 |
| 213 | 34.371 | -94.046 | 365 |
| 214 | 34.371 | -94.038 | 368 |
| 215 | 34.379 | -94.071 | 411 |
| 216 | 34.379 | -94.063 | 462 |
| 217 | 34.379 | -94.054 | 431 |
| 218 | 34.379 | -94.046 | 518 |
| 219 | 34.379 | -94.038 | 487 |
| 220 | 34.379 | -94.029 | 396 |
| 221 | 34.388 | -94.104 | 518 |
| 222 | 34.388 | -94.096 | 523 |
| 223 | 34.388 | -94.088 | 548 |
| 224 | 34.388 | -94.079 | 579 |
| 225 | 34.388 | -94.071 | 547 |
| 226 | 34.388 | -94.063 | 538 |
| 227 | 34.388 | -94.054 | 640 |
| 228 | 34.388 | -94.046 | 608 |
| 229 | 34.396 | -94.163 | 335 |
| 230 | 34.396 | -94.154 | 431 |
| 231 | 34.396 | -94.146 | 457 |
| 232 | 34.396 | -94.138 | 414 |
| 233 | 34.396 | -94.129 | 426 |
| 234 | 34.396 | -94.121 | 426 |
| 235 | 34.396 | -94.113 | 388 |
| 236 | 34.396 | -94.104 | 388 |
| 237 | 34.396 | -94.096 | 365 |
| 238 | 34.396 | -94.088 | 386 |
| 239 | 34.396 | -94.079 | 396 |
| 240 | 34.396 | -94.071 | 426 |
| 241 | 34.396 | -94.063 | 446 |
| 242 | 34.396 | -94.054 | 441 |
| 243 | 34.396 | -94.046 | 457 |
| 244 | 34.396 | -94.038 | 465 |
| 245 | 34.396 | -94.029 | 442 |
| 246 | 34.396 | -94.021 | 426 |
| 247 | 34.404 | -94.163 | 304 |
| 248 | 34.404 | -94.154 | 304 |
| 249 | 34.404 | -94.146 | 319 |
| 250 | 34.404 | -94.138 | 334 |
| 251 | 34.404 | -94.129 | 370 |
| 252 | 34.404 | -94.121 | 405 |
| 253 | 34.404 | -94.113 | 409 |
| 254 | 34.404 | -94.104 | 450 |
| 255 | 34.404 | -94.096 | 518 |
| 256 | 34.404 | -94.088 | 609 |
| 257 | 34.404 | -94.079 | 534 |
| 258 | 34.404 | -94.071 | 517 |
| 259 | 34.404 | -94.063 | 575 |
| 260 | 34.404 | -94.054 | 600 |
| 261 | 34.404 | -94.046 | 609 |
| 262 | 34.404 | -94.038 | 609 |
| 263 | 34.404 | -94.029 | 561 |

| Receptor | Latitude (deg) | Longitude (deg) | Elevation (m) |
|---|---|---|---|
| 264 | 34.413 | -94.154 | 335 |
| 265 | 34.413 | -94.146 | 432 |
| 266 | 34.413 | -94.138 | 487 |
| 267 | 34.413 | -94.129 | 499 |
| 268 | 34.413 | -94.121 | 514 |
| 269 | 34.413 | -94.113 | 442 |
| 270 | 34.413 | -94.104 | 439 |
| 271 | 34.413 | -94.096 | 395 |
| 272 | 34.413 | -94.088 | 400 |
| 273 | 34.413 | -94.079 | 426 |
| 274 | 34.413 | -94.071 | 487 |
| 275 | 34.413 | -94.063 | 548 |
| 276 | 34.413 | -94.054 | 548 |
| 277 | 34.413 | -94.046 | 548 |
| 278 | 34.413 | -94.038 | 535 |
| 279 | 34.421 | -94.146 | 304 |
| 280 | 34.421 | -94.138 | 334 |
| 281 | 34.421 | -94.129 | 396 |
| 282 | 34.421 | -94.121 | 457 |
| 283 | 34.421 | -94.113 | 457 |
| 284 | 34.421 | -94.104 | 426 |
| 285 | 34.421 | -94.096 | 411 |
| 286 | 34.421 | -94.088 | 406 |
| 287 | 34.421 | -94.079 | 396 |
| 288 | 34.421 | -94.071 | 401 |
| 289 | 34.421 | -94.063 | 397 |
| 290 | 34.429 | -94.146 | 322 |
| 291 | 34.429 | -94.138 | 334 |
| 292 | 36.946 | -90.246 | 106 |
| 293 | 36.946 | -90.229 | 102 |
| 294 | 36.954 | -90.238 | 105 |
| 295 | 36.954 | -90.229 | 102 |
| 296 | 36.954 | -90.221 | 102 |
| 297 | 36.963 | -90.238 | 114 |
| 298 | 36.963 | -90.229 | 104 |
| 299 | 36.963 | -90.221 | 102 |
| 300 | 36.963 | -90.213 | 102 |
| 301 | 36.963 | -90.204 | 102 |
| 302 | 36.963 | -90.196 | 103 |
| 303 | 36.971 | -90.229 | 108 |
| 304 | 36.971 | -90.221 | 105 |
| 305 | 36.971 | -90.213 | 102 |
| 306 | 36.971 | -90.204 | 102 |
| 307 | 36.971 | -90.196 | 102 |
| 308 | 36.971 | -90.188 | 102 |
| 309 | 36.971 | -90.179 | 102 |
| 310 | 36.971 | -90.171 | 102 |
| 311 | 36.979 | -90.221 | 121 |
| 312 | 36.979 | -90.213 | 104 |
| 313 | 36.979 | -90.204 | 102 |
| 314 | 36.979 | -90.196 | 102 |
| 315 | 36.979 | -90.188 | 102 |
| 316 | 36.979 | -90.179 | 102 |
| 317 | 36.979 | -90.171 | 102 |

| Receptor | Latitude (deg) | Longitude (deg) | Elevation (m) |
|---|---|---|---|
| 318 | 36.988 | -90.213 | 121 |
| 319 | 36.988 | -90.204 | 105 |
| 320 | 36.988 | -90.196 | 102 |
| 321 | 36.988 | -90.188 | 102 |
| 322 | 36.988 | -90.179 | 102 |
| 323 | 36.988 | -90.171 | 101 |
| 324 | 36.996 | -90.204 | 117 |
| 325 | 36.996 | -90.196 | 101 |
| 326 | 36.996 | -90.188 | 101 |
| 327 | 36.996 | -90.179 | 102 |
| 328 | 36.996 | -90.171 | 101 |
| 329 | 37.004 | -90.196 | 106 |
| 330 | 37.004 | -90.188 | 102 |
| 331 | 37.004 | -90.179 | 102 |
| 332 | 37.004 | -90.171 | 102 |
| 333 | 37.013 | -90.188 | 103 |
| 334 | 37.013 | -90.179 | 102 |
| 335 | 37.013 | -90.171 | 102 |
| 336 | 37.021 | -90.179 | 103 |
| 337 | 37.021 | -90.171 | 102 |
| 338 | 37.029 | -90.171 | 103 |

# BART FIVE FACTOR ANALYSIS ▪ KANSAS CITY POWER & LIGHT
## LA CYGNE GENERATING STATION

**VERSION 0**

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# TABLE OF CONTENTS

# LIST OF TABLES

# 1. EXECUTIVE SUMMARY

This report documents the determination of the Best Available Retrofit Technology (BART) as proposed by Kansas City Power & Light (KCP&L) for the La Cygne Generating Station located in La Cygne, Kansas. There are two boilers at La Cygne. Unit 1 is an 840 MW supercritical cyclone coal boiler that was manufactured in 1973 by Babcock and Wilcox with a scrubber for sulfur dioxide ($SO_2$) and particulate matter (PM) control and overfire air that minimizes the formation of thermal nitrogen oxides ($NO_X$). Unit 2 is a 710 MW radiant opposed-fired pulverized coal (PC) boiler that was manufactured in 1976 by Babcock and Wilcox with an electrostatic precipitator (ESP) for PM control. Unit 1 burns a blend of Powder River Basin (PRB) coal and local coal. Unit 2 burns 100 percent PRB coal.

KCP&L has determined that the two boilers at the La Cygne Generating Station contribute greater than 0.5 deciviews (dv) to visibility impairment in a federally protected Class I area when compared to a natural background. Therefore, these two sources are subject to BART. A summary of the visibility impairment attributable to the boilers is provided in Table 1-1.

**TABLE 1-1. VISIBILITY IMPAIRMENT ATTRIBUTABLE TO LA CYGNE GENERATING STATION**

| Class I Area | Visibility Impairment 98th % Δdv | Days > 0.5 Δdv |
|---|---|---|
| Wichita Mountains Wilderness | 1.02 | 57 |
| Hercules Glades Wilderness | 1.74 | 138 |
| Caney Creek Wilderness | 1.14 | 63 |
| Upper Buffalo Wilderness | 1.92 | 125 |
| Mingo Wilderness | 0.92 | 62 |

KCP&L used the guidelines in 40 CFR Part 51[1] to determine BART for the boilers. Specifically, KCP&L conducted a five-step analysis to determine BART for $SO_2$, $NO_X$, and $PM_{10}$ that included the following:

1. Identifying all available retrofit control technologies;
2. Eliminating technically infeasible control technologies;
3. Evaluating the control effectiveness of remaining control technologies;
4. Evaluating impacts and document the results;
5. Evaluating visibility impacts

Based on the five-step analysis, KCP&L proposes the following as BART:

- $NO_X$ – KCP&L proposes to meet the U.S. Environmental Protection Agency's (EPA's) presumptive BART limits of 0.10 lb/MMBtu and 0.23 lb/MMBtu for Unit 1 and Unit 2, respectively, by complying with a combined Unit 1 and Unit 2 weighted average limit. This

[1] 40 CFR 51, Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations

will be achieved by operating the currently permitted SCR on Unit 1 and by installing $NO_X$ controls on Unit 2.

- $SO_2$ – KCP&L proposes to meet the U.S. EPA's presumptive BART limit of 0.15 lb/MMBtu for Unit 1 and Unit 2 by complying with a combined Unit 1 and Unit 2 weighted average limit by installing either wet scrubbers or spray dryer absorbers (SDA) on both units.
- PM – KCP&L proposes that no additional PM controls are required for BART compliance because the PM controls would provide little visibility improvement while requiring significant capital expenditures. Although not required for BART compliance, KCP&L plans to install baghouses on Unit 1 and Unit 2 for compliance with other environmental regulations.

The proposed presumptive BART emission rates will result in reductions of the visibility impacts attributable to La Cygne Unit 1 and Unit 2. A summary of the visibility improvement based on the existing emission rates and presumptive BART emission rates is provided in Table 1-2.

**TABLE 1-2. VISIBILITY IMPAIRMENT IMPROVEMENT**

| | **Caney Creek Wilderness** | | | **Hercules Glades Wilderness** | | | **Mingo Wilderness** | | | **Upper Buffalo Wilderness** | | | **Wichita Mountains Wilderness** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement |
| Max Impact (Δdv) | 5.16 | 1.278 | 75% | 4.479 | 0.998 | 78% | 3.82 | 0.868 | 77% | 6.359 | 1.563 | 75% | 8.404 | 2.117 | 75% |
| 98% Impact (Δdv) | 1.138 | 0.227 | 80% | 1.738 | 0.357 | 79% | 0.915 | 0.177 | 81% | 1.923 | 0.415 | 78% | 1.017 | 0.205 | 80% |
| Days > 0.5 | 63 | 5 | 92% | 138 | 6 | 96% | 62 | 3 | 95% | 125 | 14 | 89% | 57 | 7 | 88% |

# 2. INTRODUCTION AND BACKGROUND

On July 1, 1999, the U.S. Environmental Protection Agency (EPA) published the final Regional Haze Rule (RHR). The objective of the RHR is to improve visibility in 156 specific areas across with United States, known as Class I areas. The Clean Air Act defines Class I areas as certain national parks (over 6000 acres), wilderness areas (over 5000 acres), national memorial parks (over 5000 acres), and international parks that were in existence on August 7, 1977.

On July 6, 2005, the EPA published amendments to its 1999 RHR, often called the Best Available Retrofit Technology (BART) rule, which included guidance for making source-specific BART determinations. The BART rule defines BART-eligible sources as sources that meet the following criteria:

(1) Have potential emissions of at least 250 tons per year of a visibility-impairing pollutant,
(2) Began operation between August 7, 1962 and August 7, 1977, and
(3) Are included as one of the 26 listed source categories in the guidance.

A BART-eligible source is subject to BART if the source is "reasonably anticipated to cause or contribute to visibility impairment in any federal mandatory Class I area." EPA has determined that a source is reasonably anticipated to cause or contribute to visibility impairment if the $98^{th}$ percentile visibility impacts from the source are greater than 0.5 deciviews (dv) when compared against a natural background. Air quality modeling is the tool that is used to determine a source's visibility impacts.

Once it is determined that a source is subject to BART, a BART determination must address air pollution control measures for the source. The visibility regulations define BART as follows:

> *"…an emission limitation based on the degree of reduction achievable through the application of the best system of continuous emission reduction for each pollutant which is emitted by…[a BART-eligible source]. The emission limitation must be established on a case-by-case basis, taking into consideration the technology available, the cost of compliance, the energy and non air quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonable be anticipated to result from the use of such technology.*

Specifically, the BART rule states that a BART determination should address the following five statutory factors:

1. Existing controls
2. Cost of controls
3. Energy and non-air quality environmental impacts
4. Remaining useful life of the source
5. Degree of visibility improvement as a result of controls

Further, the BART rule indicates that the five basic steps in a BART analysis can be summarized as follows:

1. Identify all available retrofit control technologies;
2. Eliminate technically infeasible control technologies;
3. Evaluate the control effectiveness of remaining control technologies;
4. Evaluate impacts and document the results;
5. Evaluate visibility impacts

A BART determination should be made for each visibility affecting pollutant (VAP) by following the five steps listed above for each VAP.

KCP&L performed a BART applicability analysis for La Cygne Unit 1 and Unit 2 and determined the units are subject to BART. The details of the applicability determination can be found in Section 3. Subsequently, KCP&L performed an analysis to determine BART for each VAP for Unit 1 and Unit 2. The VAPs emitted by La Cygne Unit 1 and Unit 2 include $NO_x$, $SO_2$, and particulate matter with a mass mean diameter smaller than ten microns ($PM_{10}$) of various forms (filterable coarse particulate matter [$PM_c$], filterable fine particle matter [$PM_f$], elemental carbon [EC], inorganic condensable particulate matter [IOR CMP] as sulfates [$SO_4$], and organic condensable particulate matter [OR CMP] also referred to as secondary organic aerosols [SOA]). The BART determinations for $SO_2$, $NO_X$, and $PM_{10}$ can be found in Sections 4, 5, and 6, respectively.

## 2.1 PRESUMPTIVE LIMITS

EPA established presumptive limits in the BART guidelines for electric generating units (EGUs). The presumptive limits were established by reviewing BART-eligible units and determining a level of emissions reductions that would be cost effective. The EPA's BART guidelines state the following with regard to presumptive BART for $SO_2$

> *"You must require 750 MW power plants to meet specific control levels for $SO_2$ of either 95 percent control or 0.15 lb/MMBtu… For coal fired EGUs with an existing post combustion $SO_2$ controls achieving less than 50 percent removal efficiencies, we recommend that you evaluate construction a new FGD system to meet the same emission limit as above (95 percent removal or 0.15 lb/MMBtu)"*

For power plants greater than 750 MW, EPA requires that state agencies apply the presumptive BART limit as a floor for $SO_2$. The $SO_2$ presumptive limit for both Unit 1 and Unit 2 is 0.15 lb/MMBtu.

Similarly for $NO_X$, the guidelines state:

> *"For coal-fired EGUs greater than 200 MW located at greater than 750 MW power plants and operating without post-combustion controls (i.e. selective catalytic reduction or selective non-catalytic reduction), we have provided presumptive $NO_X$ limits differentiated by boiler design and type of coal burned."*

The guidelines go on to state for cyclone boilers:

> *"Because of the relatively high $NO_X$ emission rates of cyclone units, SCR is more cost-effective than the use of current combustion control technology for these units. The use of SCRs at cyclone units burning bituminous coal, sub-bituminous coal, and lignite should enable the units to cost-effectively meet $NO_X$ rates of 0.10 lbs/MMBtu.*

*As a result, we are establishing a presumptive $NO_X$ limit of 0.10 lb/MMBtu based on the use of SCR for coal-fired cyclone units greater than 200 MW located at 750 MW power plants.*

Therefore, for units greater than 200 MW located at power plants greater than 750 MW, the presumptive limits are also a floor for $NO_X$. Since La Cygne Unit 1 is a cyclone boiler, the presumptive limit is 0.10 lb/MMBtu. For La Cygne Unit 2, which is a dry-bottom wall-fired boiler combusting sub-bituminous coal, the $NO_X$ presumptive limit is 0.23 lb/MMBtu.

The BART guidelines do not specify presumptive BART limits for $PM_{10}$ emissions.

## 2.2 EXISTING CONTROLS

La Cygne Unit 1 and Unit 2 have existing emission controls. Unit 1 is currently equipped with a scrubber for $SO_2$ and particulate control and overfire air that minimizes the formation of thermal $NO_X$. KCPL is in the process of voluntarily constructing an SCR system for Unit 1 which will further reduce $NO_X$ emissions. The SCR project is scheduled to be operational by May 2007. Unit 2 is equipped with an electrostatic precipitator (ESP) for particulate control.

# 3. BART APPLICABILITY DETERMINATION

As stated in Section 2, a BART-eligible source is subject-to-BART if the source is "reasonably anticipated to cause or contribute to visibility impairment in any federal mandatory Class I area." EPA has determined that a source is reasonably anticipated to cause or contribute to visibility impairment if the $98^{th}$ percentile of the visibility impacts from the source is greater than 0.5 deciviews (dv) when compared against a natural background. KCP&L conducted air quality modeling to predict the existing visibility impairment attributable to La Cygne Unit 1 and Unit 2 in the following Class I areas:

- ▲ Wichita Mountains Wilderness (Fish and Wildlife Service [FWS])
- ▲ Hercules Glades Wilderness (Forest Service [FS])
- ▲ Upper Buffalo Wilderness (FS)
- ▲ Caney Creek Wilderness (FS)
- ▲ Mingo Wilderness (FWS)

The modeling methods and procedures that were followed were provided to the Kansas Department of Health and Environment (KDHE) in a November 2006 modeling protocol. In response to comments provided to KCP&L by KDHE regarding the modeling protocol, the only change made to the modeling methods and procedures documented in the protocol was to correct a typographical error for the November monthly humidity factor for Mingo from 3.4 to the correct value of 3.1. Since this change did not warrant a new version of the protocol, the documentation of this change is provided in this report. Table 3-1 summarizes the emission rates that were modeled for $SO_2$, $NO_X$, and $PM_{10}$, including the speciated $PM_{10}$ emissions. The $SO_2$ and $NO_x$ emission rates are the highest actual 24-hour emission rates based on 2002-2004 continuous emissions monitoring system (CEMS) data. The $PM_{10}$ emission rates are the calculated highest emission rates based on fuel data from 2002-2004 and AP-42 emission factors. The total $PM_{10}$ emission rates include both the filterable and condensable fractions and are speciated into the following:

- ▲ Coarse particulate matter ($PM_C$)
- ▲ Fine particulate matter ($PM_f$)
- ▲ Sulfates ($SO_4$)
- ▲ Secondary organic aerosols (SOA)
- ▲ Elemental carbon (EC)

**TABLE 3-1. HIGHEST ACTUAL 24-HOUR $SO_2$ AND $NO_X$ EMISSIONS AND CALCULATED HIGHEST $PM_{10}$ EMISSIONS (AS AN HOURLY EQUIVALENT)**

| | $SO_2$ (lb/hr) | $NO_X$ (lb/hr) | Total $PM_{10}$ (lb/hr) | $SO_4$ (lb/hr) | $PM_c$ (lb/hr) | $PM_f$ (lb/hr) | SOA (lb/hr) | EC (lb/hr) |
|---|---|---|---|---|---|---|---|---|
| La Cygne - Unit 1 | 6,151.15 | 11,589.52 | 53.79 | 34.37 | 4.92 | 5.68 | 8.59 | 0.22 |
| La Cygne - Unit 2 | 8,316.15 | 3,543.47 | 94.92 | 28.12 | 33.20 | 25.58 | 7.03 | 0.98 |

Table 3-2 summarizes the stack parameters that were used to model La Cygne Unit 1 and Unit 2. It should be noted that the good engineering practice (GEP) stack heights were modeled instead of the actual stack heights since the GEP stack heights are less than the actual stack heights.

**TABLE 3-2. SUMMARY OF STACK PARAMETERS**

| | La Cygne Unit 1 | La Cygne Unit 2 |
|---|---|---|
| Latitude (degrees) | 38.3486 | 38.3476 |
| Longitude (degrees) | -94.6456 | -94.6456 |
| Actual Stack height (ft) | 700 | 700 |
| GEP Stack height (ft) | 591.2 | 597.8 |
| Stack Diameter (ft) | 23 | 24 |
| Exhaust Velocity (ft/s) | 92.7 | 100.8 |
| Exhaust Temperature (F) | 127 | 281 |

The results of the modeling indicate that the 98$^{th}$ percentile of the visibility impacts attributable to La Cygne Unit 1 and Unit 2 are greater than 0.5 dv when compared against a natural background. Since the visibility impacts are greater than 0.5 Δdv, La Cygne Unit 1 and Unit 2 are subject to BART. The results of the modeling are summarized in Table 3-3.

**TABLE 3-3. SUMMARY OF 98$^{TH}$ PERCENTILE VISIBILITY IMPACTS AND NUMBER OF DAYS WITH VISIBILITY IMPACT GREATER THAN 0.5 ΔDV**

| | Visibility Impairment | |
|---|---|---|
| Class I Area | 98th % Δdv | Days > 0.5 Δdv |
| Wichita Mountains Wilderness | 1.02 | 57 |
| Hercules Glades Wilderness | 1.74 | 138 |
| Caney Creek Wilderness | 1.14 | 63 |
| Upper Buffalo Wilderness | 1.92 | 125 |
| Mingo Wilderness | 0.92 | 62 |

Table 3-4 provides a breakdown of the visibility impacts listed in Table 3-3 by each VAP.

**TABLE 3-4. BREAKDOWN OF POLLUTANT SPECIFIC CONTRIBUTIONS TO VISIBILITY**

| Class I Area | Visibility Impairment Attributable to $SO_4$ (%) | Visibility Impairment Attributable to $NO_3$ (%) | Visibility Impairment Attributable to SOA (%) | Visibility Impairment Attributable to EC (%) | Visibility Impairment Attributable to $PM_c$ (%) | Visibility Impairment Attributable to $PM_f$ (%) | Total Visibility Impairment (Δdv) |
|---|---|---|---|---|---|---|---|
| Wichita Mountains Wilderness | 82.89 | 17.02 | 0.05 | 0.01 | 0.01 | 0.03 | 1.017 |
| Hercules Glades Wilderness | 19.63 | 79.99 | 0.20 | 0.04 | 0.04 | 0.10 | 1.738 |
| Caney Creek Wilderness | 24.32 | 75.46 | 0.12 | 0.02 | 0.02 | 0.06 | 1.138 |
| Upper Buffalo Wilderness | 20.20 | 79.53 | 0.15 | 0.03 | 0.02 | 0.07 | 1.923 |
| Mingo Wilderness | 42.26 | 57.61 | 0.07 | 0.01 | 0.00 | 0.03 | 0.915 |

As shown in Table 3-4, the most significant contributors to the visibility impairment are sulfates ($SO_4$) and nitrates ($NO_3$). The $SO_4$ contribution is primarily from the chemical conversion of $SO_2$ emitted by Unit 1 and Unit 2 to $SO_4$; a very small fraction is from $SO_4$ emitted as condensable particulate. The $NO_3$ contribution is entirely from the chemical conversion of $NO_X$ emitted from Unit

1 and Unit 2. The contribution of $PM_{10}$ to the total visibility impairment can be estimated as the sum of the contributions from SOA, EC, PMc, and PMf. The $PM_{10}$ contribution is much smaller (<1%) than the contribution from $SO_2$ and $NO_X$.

$SO_2$ emissions at coal-fired EGUs are the result of the oxidation of the sulfur compounds in the coal during the combustion process.

The existing maximum 24-hour $SO_2$ emission rates that were modeled for the BART applicability determination are summarized in Table 4-1.

**TABLE 4-1. EXISTING MAXIMUM 24-HOUR $SO_2$ EMISSION RATES**

| | Maximum 24-Hour Heat Input (MMBtu/24hr) | $SO_2$ Emission Rate (lb/hr) | $SO_2$ Emission Rate (lb/MMBtu) |
|---|---|---|---|
| La Cygne - Unit 1 | 223,488 | 6,151.15 | 0.66 |
| La Cygne - Unit 2 | 198,911 | 8,316.15 | 1.00 |

## 4.1 IDENTIFICATION OF AVAILABLE RETROFIT $SO_2$ CONTROL TECHNOLOGIES

Step 1 of the BART determination is the identification of all available retrofit $SO_2$ control technologies. A list of control technologies was obtained by reviewing the U.S. EPA's Clean Air Technology Center, control equipment vendor information, publicly-available air permits, applications, and BART analyses, and technical literature published by the U.S. EPA and Regional Planning Organizations (RPOs).

The available retrofit $SO_2$ control technologies are summarized in Table 4-2.

**TABLE 4-2. AVAILABLE $SO_2$ CONTROL TECHNOLOGIES**

| $SO_2$ Control Technologies |
|---|
| Dry Sorbent Injection<br>Spray Dryer Absorber (SDA) i.e., Semi-Dry Scrubber<br>Wet Scrubber<br>Circulating Dry Scrubber (CDS) |

All of the technologies listed in Table 4-2 involve removing the $SO_2$ in the exhaust gas, which is also known as flue gas desulfurization (FGD).

## 4.2 ELIMINATE TECHNICALLY INFEASIBLE $SO_2$ CONTROL TECHNOLOGIES

Step 2 of the BART determination is to eliminate technically infeasible $SO_2$ control technologies that were identified in Step 1.

### 4.2.1 DRY SORBENT INJECTION

Dry sorbent injection involves the injection of a lime or limestone powder into the exhaust gas stream where $SO_2$ becomes entrained in the lime. The stream is then passed through a fabric filter to remove the sorbent and entrained $SO_2$. The process was developed as a lower cost FGD option because the mixing of the $SO_2$ and lime occurs directly in the exhaust gas stream instead of in a separate tower. Depending on the residence time and gas stream temperature, sorbent injection control efficiency is typically between 40 and 60 percent.[2] This control is a technically feasible option for the control of $SO_2$ from La Cygne Unit 1 and Unit 2.

### 4.2.2 SPRAY DRYER ABSORPTION (SDA)

Spray dryer absorption is a semi-dry scrubbing system that sprays a fine mist of lime slurry into an absorption tower where the $SO_2$ is absorbed by the slurry droplets. The absorption of the $SO_2$ leads to the formation of calcium sulfite and calcium sulfate within the droplets. The liquid-to-gas ratio is such that the heat from the exhaust gas causes the water to evaporate before the droplets reach the bottom of the tower. This leads to the formation of a dry powder which is carried out with the gas and collected with a fabric filter. Existing spray dryer absorption control efficiencies range from 60 to 95 percent.[3] This control is a technically feasible option for the control of $SO_2$ from La Cygne Unit 1 and Unit 2.

### 4.2.3 WET SCRUBBER

Wet scrubbing involves scrubbing the exhaust gas stream with a slurry comprised of lime or limestone in suspension. The process takes place in a wet scrubbing tower located downstream of a PM control device such as a fabric filter or an ESP to prevent the plugging of spray nozzles and other problems caused by the presence of particulates in the scrubber. Similarly to the chemistry illustrated above for spray dryer absorption, the $SO_2$ in the gas stream reacts with the lime or limestone slurry to form calcium sulfite and calcium sulfate. Wet lime scrubbing is capable of achieving 80-95 percent control.[3] This control is a technically feasible option for the control of $SO_2$ from La Cygne Unit 1 and Unit 2.

### 4.2.4 CIRCULATING DRY SCRUBBER (CDS)

In the circulating dry scrubbing process, the flue gas is introduced into the bottom of a reactor vessel at high velocity through a venturi nozzle; the exhaust is mixed with water, hydrated lime, recycled flyash and CDS reaction products. The intensive gas-solid mixing that occurs in the reactor promotes the reaction of sulfur oxides in the flue gas with the dry lime particles. The mixture of reaction products (calcium sulfite/sulfate), unreacted lime, and fly ash is carried out with the exhaust and collected in an ESP or fabric filter. A large portion of the collected particles is recycled to the reactor to sustain the bed and improve lime utilization. CDS absorbers have been installed with both fabric filters and ESPs for particulate control. The control efficiency of a CDS is similar to that of an SDA. This

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[2] "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities" Northeast States for Coordinated Air Use Management (NESCAUM), March 2005.

[3] EPA Module 6: Air Pollutants and Control Techniques

control is a technically feasible option for the control of $SO_2$ from La Cygne Unit 1 and Unit 2.

## 4.3 RANK OF TECHNICALLY FEASIBLE $SO_2$ CONTROL OPTIONS BY EFFECTIVENESS

The third step in the BART analysis is to rank the technically feasible options according to effectiveness. Table 4-3 provides a ranking of the control efficiencies for the controls listed in the previous section.

**TABLE 4-3. CONTROL EFFECTIVENESS OF TECHNICALLY FEASIBLE $SO_2$ CONTROL TECHNOLOGIES**

| Control Technology | Estimated Control Efficiency |
|---|---|
| Wet Scrubber | ~80-95% |
| Spray Dryer Absorber (SDA) | ~60-95% |
| Circulating Dry Scrubber (CDS) | ~60-95% |
| Dry Sorbent Injection | ~40-60% |

As seen in Table 4-3, dry sorbent injection has the lowest estimated control efficiency and will therefore no longer be considered for BART.

It should be noted that Unit 1 has an existing scrubber for $SO_2$ control; however, the current control efficiency of the scrubber is below the efficiencies for the FGD controls listed in Table 4-3.

## 4.4 EVALUATION OF IMPACTS FOR FEASIBLE $SO_2$ CONTROLS

Step four for the BART analysis procedure is the impact analysis. The BART determination guidelines list the four factors to be considered in the impact analysis:

- Cost of compliance
- Energy impacts
- Non-air quality impacts; and
- The remaining useful life of the source

### 4.4.1 COST OF COMPLIANCE

The cost of compliance was evaluated for the two technologies with the highest $SO_2$ control efficiencies: wet scrubbers and SDA systems. The typical annual cost effectiveness for both wet scrubbers and SDA systems is \$200 to \$500 per ton of $SO_2$ removed at the highest removal efficiencies. The cost effectiveness was estimated from a published cost in a technical paper.[4] This cost estimate is considered to be study grade, which is +/- 30 percent accuracy.

[4] "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities" Northeast States for Coordinated Air Use Management (NESCAUM), March 2005.

In the BART guidelines, EPA calculated that that the majority of BART-eligible units could meet the presumptive limits at a cost of \$400 to \$2,000 per ton of $SO_2$ removed, based on the use of wet scrubbers and SDA systems. Based on EPA's guidelines as to what is considered cost effective for $SO_2$ removal and the annual cost effectiveness of \$200 to \$500 published in the technical paper, wet scrubbers and SDA systems are cost effective.

### 4.4.2 ENERGY IMPACTS AND NON-AIR QUALITY IMPACTS

FGD systems require electricity to operate the blowers and pumps needed for the operation of the scrubbers. The generation of the electricity will most likely involve fuel combustion, which will cause emissions. While the required electricity will result in emissions, the emissions should be small compared to the reduction in $SO_2$ that would be gained by operating an FGD system.

Wet FGD systems generate wastewater and sludge that must be treated. This places additional burdens on the wastewater treatment and solid waste management capabilities. If wet scrubbing produces calcium sulfite sludge, the sludge will be water-laden, and it must be stabilized for landfilling. If wet scrubbing produces calcium sulfate sludge, it is stable and easy to dewater. However, control costs will be higher because additional equipment is required.

Disposal of material from dry FGD systems is also required and will result in landfill impacts.

### 4.4.3 REMAINING USEFUL LIFE

The remaining useful life of Unit 1 and Unit 2 do not impact the annualized capital costs because the useful lives of the units are anticipated to be at least as long as the capital cost recovery period, which is 20 years.

## 4.5 EVALUATION OF VISIBILITY IMPACT OF FEASIBLE $SO_2$ CONTROLS

The final impact analysis was conducted to assess the visibility improvement for existing emission rates when compared to the presumptive BART emission rates. The existing and presumptive BART emission rates were modeled using CALPUFF. The existing emission rates are the same rates that were modeled for the BART applicability analysis. The BART rates are the presumptive limits (in lb/MMBtu) multiplied by the historical maximum daily heat inputs. A sample calculation of the $SO_2$ presumptive BART hourly equivalent emission rate for Unit 1 is provided as follows:

$$P * HI * \frac{day}{24hr} = 1{,}396.8 \text{ lb/hr}$$

Where:
P (Presumptive BART Emission Rate) = 0.15 lb/MMBtu
HI (2002-2004 maximum daily heat input) = 223,488 MMBtu/day

The existing and presumptive BART emission rates are summarized in Table 4-4.

**TABLE 4-4. EXISTING AND PRESUMPTIVE BART EMISSION RATES**

| | Existing Emission Rate | | | Presumptive BART Emission Rate | | |
|---|---|---|---|---|---|---|
| | $SO_2$ (lb/hr) | $NO_X$ (lb/hr) | $PM_{10}$ (lb/hr) | $SO_2$ (lb/hr) | $NO_X$ (lb/hr) | $PM_{10}$ (lb/hr) |
| La Cygne - Unit 1 | 6,151.15 | 11,589.52 | 53.79 | 1,396.80 | 931.20 | 53.79 |
| La Cygne - Unit 2 | 8,316.15 | 3,543.47 | 94.92 | 1,243.19 | 1,906.23 | 94.92 |

The visibility improvement due to the presumptive BART limits was calculated as the difference between the existing visibility impairment and the visibility impairment for the presumptive rates. A comparison of the existing visibility impacts and the visibility impacts based on the presumptive BART emission rates, including the maximum modeled visibility impact, $98^{th}$ percentile modeled visibility impact, and the number of days with a modeled visibility impact greater than 0.5 $\Delta$dv, for each Class I area is provided in Table 4-5. It should be noted that the visibility impacts presented in Table 4-5 are based on the application of the presumptive BART limits for both $SO_2$ and $NO_x$. The analysis included the presumptive BART limits from both $SO_2$ and $NO_X$ in order to determine the overall visibility improvement that would be gained from applying BART to both pollutants. The presumptive BART limits for $NO_X$ are discussed in Section 5.

**TABLE 4-5.MODELED IMPACTS BASED ON EXISTING AND PRESUMPTIVE BART EMISSION RATES**

| | Caney Creek Wilderness | | | Hercules Glades Wilderness | | | Mingo Wilderness | | | Upper Buffalo Wilderness | | | Wichita Mountains Wilderness | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement |
| Max Impact ($\Delta$dv) | 5.16 | 1.28 | 75% | 4.48 | 1.00 | 78% | 3.82 | 0.87 | 77% | 6.36 | 1.56 | 75% | 8.40 | 2.12 | 75% |
| 98% Impact ($\Delta$dv) | 1.14 | 0.23 | 80% | 1.74 | 0.36 | 79% | 0.92 | 0.18 | 81% | 1.92 | 0.42 | 78% | 1.02 | 0.21 | 80% |
| Days > 0.5 | 63 | 5 | 92% | 138 | 6 | 96% | 62 | 3 | 95% | 125 | 14 | 89% | 57 | 7 | 88% |

As seen in Table 4-5, the visibility impacts (the maximum visibility impact, $98^{th}$ percentile visibility impact, and the number of days with a visibility impact greater than 0.5 $\Delta$dv) for each Class I area are lower for the presumptive BART emission rates than for the existing emission rates.

## 4.6 PROPOSED BART FOR $SO_2$

KCP&L has determined that the $SO_2$ BART emission rate for Unit 1 and Unit 2 is the presumptive emission rate of 0.15 lb/MMBtu. KCP&L is proposing to meet the presumptive BART $SO_2$ emission rate of 0.15 lb/MMBtu for each unit by complying with a combined Unit 1 and Unit 2 weighted average limit. KCP&L will meet this limit by installing scrubbing technology (i.e., either wet scrubber or SDA). Wet scrubbers and SDA systems achieve the highest levels of $SO_2$ control. In addition, the costs of compliance associated with both controls are similar, so no cost effectiveness is gained by choosing one control over the other. KCP&L will select one of these control options at a later date pending several factors, including anticipated performance, availability, and market conditions. Performance, availability, and market conditions at the time of the BART implementation may drive the selection of the control option. At that time, a more detailed study may determine that one control is more favorable than the other.

$NO_X$ from coal-fired EGUs is formed by three fundamentally different mechanisms. The principle $NO_X$ formation mechanism, thermal $NO_X$, arises from the thermal dissociation and subsequent reaction of nitrogen ($N_2$) and oxygen ($O_2$) molecules in the combustion air. Most thermal $NO_X$ forms in the highest temperature regions of the combustion chamber (i.e., the air/fuel interface). The second $NO_X$ formation mechanism, prompt $NO_X$, arises from early reactions of nitrogen intermediaries and hydrocarbon radicals in the fuel. The final $NO_X$ formation mechanism, fuel $NO_X$, arises from the evolution and reaction of fuel bound nitrogen compounds with oxygen.

The existing maximum daily $NO_X$ emission rates that were modeled for the BART applicability determination are summarized in Table 5-1.

**TABLE 5-1. EXISTING MAXIMUM 24-HOUR $NO_X$ EMISSION RATE**

| | Maximum 24-Hour Heat Input (MMBtu/24hr) | $NO_X$ Emission Rate (lb/hr) | $NO_X$ Emission Rate (lb/MMBtu) |
|---|---|---|---|
| La Cygne - Unit 1 | 223,488 | 11,589.52 | 1.24 |
| La Cygne - Unit 2 | 198,911 | 3,543.47 | 0.43 |

## 5.1 IDENTIFICATION OF AVAILABLE RETROFIT $NO_X$ CONTROL TECHNOLOGIES

Step 1 of the BART determination is the identification of all available retrofit $NO_X$ control technologies. A list of control technologies was obtained by reviewing the U.S. EPA's Clean Air Technology Center, control equipment vendor information, publicly-available air permits, applications, and BART analyses, and technical literature published by the U.S. EPA and the RPOs.

The available retrofit $NO_X$ control technologies are summarized in Table 5-2.

**TABLE 5-2. AVAILABLE $NO_X$ CONTROL TECHNOLOGIES**

| $NO_X$ Control Technologies | |
|---|---|
| Combustion Controls | Flue Gas Recirculation (FGR) |
| | Overfire Air (OFA) |
| | Low $NO_X$ Burners (LNB) and Ultra Low $NO_X$ Burners (ULNB) |
| Post-Combustion Controls | Selective Catalytic Reduction (SCR) |
| | Selective Non-Catalytic Reduction (SNCR) |

$NO_X$ emissions controls, as listed in Table 5-2, can be categorized as combustion or post-combustion controls. Combustion controls, including flue gas recirculation (FGR), overfire air (OFA), and Low

$NO_X$ Burners (LNB), reduce the peak flame temperature and excess air in the furnace which minimizes $NO_X$ formation. Post-combustion controls, such as selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) convert $NO_X$ in the flue gas to molecular nitrogen and water.

## 5.2 ELIMINATE TECHNICALLY INFEASIBLE $NO_X$ CONTROL TECHNOLOGIES

Step 2 of the BART determination is to eliminate technically infeasible $NO_X$ control technologies that were identified in Step 1.

### 5.2.1 COMBUSTION CONTROLS

#### 5.2.1.1 FLUE GAS RECIRCULATION (FGR)

FGR uses flue gas as an inert material to reduce flame temperatures. In a typical flue gas recirculation system, flue gas is collected from the heater or stack and returned to the burner via a duct and blower. The addition of flue gas reduces the oxygen content of the "combustion air" (air + flue gas) in the burner. The lower oxygen level in the combustion zone reduces flame temperatures; which in turn reduces thermal $NO_X$ formation. When operated without additional controls, the $NO_X$ control efficiency range for FGR is 30 percent to 50 percent. When coupled with LNB the control efficiency increases to 50-72 percent.[5] This control is a technically feasible option for the control of $NO_X$ from La Cygne Unit 1 and Unit 2.

#### 5.2.1.2 OVERFIRE AIR (OFA)

OFA diverts a portion of the total combustion air from the burners and injects it through separate air ports above the top level of burners. Staging of the combustion air creates an initial fuel-rich combustion zone with a lower peak flame temperature. This reduces the formation of thermal $NO_X$ by lowering combustion temperature and limiting the availability of oxygen in the combustion zone where $NO_X$ is most likely to be formed.

OFA as a single $NO_X$ control technique may reduce $NO_X$ emissions by 25 to 55 percent. When combined with LNB, reductions of up to 60 percent may result.[6] KCP&L currently uses OFA on La Cygne Unit 1, and this is a technically feasible option for the control of $NO_X$ from La Cygne Unit 2.

#### 5.2.1.3 LOW AND ULTRA LOW $NO_X$ BURNERS

LNB technology utilizes advanced burner design to reduce $NO_X$ formation through the restriction of oxygen, lowering of flame temperature, and/or reduced residence time. LNB is a staged combustion process that is designed to

[5] "Midwest Regional Planning Organization Boiler Best Available Retrofit Technology (BART) Engineering Analysis" MACTEC, March 30, 2005.

[6] "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities" Northeast States for Coordinated Air Use Management (NESCAUM), March 2005

split fuel combustion into two zones. In the primary zone, $NO_X$ formation is limited by either one of two methods. Under staged fuel-rich conditions, low oxygen levels limit flame temperatures resulting in less $NO_X$ formation. The primary zone is then followed by a secondary zone in which the incomplete combustion products formed in the primary zone act as reducing agents. Alternatively, under staged fuel-lean conditions, excess air will reduce flame temperature to reduce $NO_X$ formation. In the secondary zone, combustion products formed in the primary zone act to lower the local oxygen concentration, resulting in a decrease in $NO_X$ formation. The estimated $NO_X$ control efficiency for LNBs in high temperature applications is 25 percent. However when coupled with FGR or SNCR these efficiencies increase to 50-72 and 50-89 percent, respectively.[7]

ULNBs may incorporate a variety of techniques including induced FGR, steam injection, or a combination of techniques. These burners combine the benefits of flue gas recirculation and LNB control technologies. Rather than a system of fans and blowers (like FGR), the burner is designed to recirculate hot, oxygen depleted flue gas from the flame or firebox back into the combustion zone. This leads to a reduction in the average oxygen concentration in the flame without reducing the flame temperature below temperatures necessary for optimal combustion efficiency.

The estimated $NO_X$ control efficiency for ULNBs in high temperature applications is 50 percent. Newer designs have yielded efficiencies of between 75-85 percent. When coupled with SCR, efficiencies in the range of 85-97 percent can be obtained.[8]

LNBs and ULNBs are technically feasible for tangential and wall-fired boilers of various sizes, but are not feasible for other boiler types such as cyclone or stoker.[9] Since La Cygne Unit 1 is a cyclone boiler, LNBs and ULNBs are not technically feasible for the control of $NO_x$ from this boiler. LNBs and ULNBs are technically feasible for the control of $NO_x$ from La Cygne Unit 2.

### 5.2.2 POST COMBUSTION CONTROLS

$NO_X$ can be reduced to molecular nitrogen ($N_2$) in add-on systems located downstream of the furnace. The two main post-combustion control techniques in commercial service are SCR and SNCR.

#### 5.2.2.1 SELECTIVE CATALYTIC REDUCTION

SCR refers to the process in which $NO_X$ is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. The process is termed

[7] "Midwest Regional Planning Organization Boiler Best Available Retrofit Technology (BART) Engineering Analysis" MACTEC, March 30, 2005.

[8] Interim White Paper “Source Category: Electric Generating Units” Midwest RPO Candidate Control Measures, December 9, 2005

9 AP 42, Fifth Edition, Volume I Chapter 1 Section 1.1.4.3

selective because the ammonia preferentially reacts with $NO_X$ rather than oxygen, although the oxygen enhances the reaction and is a necessary component of the process. The overall reactions can be written:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$
$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

The SCR process requires a reactor, a catalyst, and an ammonia storage and injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet $NO_X$ concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. The $NO_X$ control efficiency range for SCR is 70 to 90 percent.[10] This control is a technically feasible option for the control of $NO_X$ from La Cygne Unit 1 and Unit 2.

#### 5.2.2.2 SELECTIVE NON-CATALYTIC REDUCTION

In SNCR systems, a reagent is injected into the flue gas in the furnace within an appropriate temperature window. The $NO_X$ and reagent (ammonia or urea) react to form nitrogen and water. A typical SNCR system consists of reagent storage, multi-level reagent-injection equipment, and associated control instrumentation. The SNCR reagent storage and handling systems are similar to those for SCR systems. However, because of higher stoichiometric ratios, both ammonia and urea SNCR processes require three or four times as much reagent as SCR systems to achieve similar $NO_X$ reductions. The $NO_X$ control efficiency range for SNCR is 25 to 50 percent.[11] This control is a technically feasible option for the control of $NO_X$ from La Cygne Unit 1 and Unit 2.

## 5.3 RANK OF TECHNICALLY FEASIBLE $NO_X$ CONTROL OPTIONS BY EFFECTIVENESS

The third step in the BART analysis is to rank the technically feasible options according to effectiveness.

[10] Ibid.

[11] Interim White Paper "Source Category: Electric Generating Units" Midwest RPO Candidate Control Measures, December 9, 2005.

**TABLE 5-3. CONTROL EFFECTIVENESS OF TECHNICALLY FEASIBLE $NO_X$ CONTROL TECHNOLOGIES**

| Control Technology | Estimated Control Efficiency (%) |
|---|---|
| SCR | ~70-90 |
| OFA/LNB* | ~30-60 |
| LNB* | ~25-50 |
| FGR | ~30-50 |
| SNCR | ~25-50 |
| OFA | ~25-55 |

*LNBs are technically feasible for La Cygne Unit 2 only, they are not technically feasible for La Cygne Unit 1.

## 5.4 EVALUATION OF IMPACTS FOR FEASIBLE $NO_X$ CONTROLS

Step four for the BART analysis procedure is the impact analysis. The BART determination guidelines list four factors to be considered in the impact analysis:

- Cost of compliance
- Energy impacts
- Non-air quality impacts; and
- The remaining useful life of the source

### 5.4.1 COST OF COMPLIANCE

Control Costs

The capital costs, operating costs, and cost effectiveness for combustion controls and SCR were estimated for La Cygne Unit 2 using an EPA cost estimate method outlined in the document *Nitrogen Oxides ($NO_X$), Why and How They Are Controlled.*[12] These control options were selected because they provide the highest levels of control and are commonly used for $NO_X$ control in large utility boilers. For the purposes of this analysis, LNB with OFA was used to represent a combustion controls system capable of achieving a $NO_X$ emission rate of 0.23 lb/MMBtu.

The EPA cost method relies on cost factors for capital costs, annual fixed operating and maintenance costs, and annual variable operating and maintenance costs for each of the control technologies. A summary of the cost factors is provided in Table 5-4.

[12] *Nitrogen Oxides ($NO_X$), Why and How They Are Controlled.* EPA 456/F-99-006R, November 1999.

**TABLE 5-4. $NO_X$ CONTROL TECHNOLOGY COST FACTORS***

| Control Technology | Capacity (MW) | Capital Cost ($/kW) | Fixed O&M ($/kW/yr) | Variable O&M (mils/kWh) | Capital Cost ($) | Annualized Capital Cost** ($/yr) | Annual Fixed O&M Cost ($/yr) | Annual Variable O&M Cost ($/yr) | Total Annual Cost ($/yr) |
|---|---|---|---|---|---|---|---|---|---|
| Combustion Controls System[§] | 750 | 22.8 | 0.35 | 0.07 | 17,100,000 | 2,008,566 | 262,500 | 459,900 | 2,730,966 |
| SCR | 750 | 69.7 | 6.12 | 0.24 | 52,275,000 | 6,140,222 | 4,590,000 | 1,576,800 | 12,307,022 |

*These cost factors are in 1997 dollars. Table 5-5 shows the capital costs, annual fixed O&M costs, and annual variable O&M costs in 2005 dollars.

**The annualized cost is based on a recovery period of 20 years, assuming 10% interest. The capital recovery factor (CRF) of 0.11746 was obtained from EPA's Air Pollution Control Cost Manual, Sixth Edition. EPA 452/B-02-001, January 2002.

[§]For the purposes of this analysis, the cost of a combustion control system is represented by a LNB w/OFA system capable of achieving a $NO_X$ emission rate of 0.23 lb/MMBtu. As KCP&L is proposing not to commit to specific combustion controls at this time, KCP&L is using LNB w/ OFA to represent combustion control equipment that can achieve a $NO_X$ rate of 0.23 lb/MMBtu.

These cost estimates are considered to be study grade, which is +/- 30 percent accuracy. It is likely that these costs are low, since the costs may not reflect the current high market price for steel and other increased costs associated with high demand.

KCP&L is in the process of constructing an SCR system on La Cygne Unit 1. Since SCR provides the highest level of control there is no need to evaluate the cost for other controls. Construction on the SCR system is scheduled to be operational in May 2007.

Annual Tons Reduced

The annual tons reduced that were used in the cost effectiveness calculations for $NO_X$ controls on La Cygne Unit 2 were estimated by subtracting the estimated controlled annual emission rates from the existing annual emission rates. The existing annual emission rates were the highest 365-day rolling totals as determined from CEMS data from 2002-2004.

The controlled annual emission rates were estimated based on the controlled $NO_X$ emission rates for each control method in lb/MMBtu. These emission rates were multiplied by the maximum 365-day rolling heat input as determined from CEMS data from 2002-2004.

A sample of the controlled annual emission rate is provided below for combustion controls with a controlled emission rate of 0.23 lb/MMBtu:

$$0.23 lb / MMBtu \times 63{,}507{,}314 MMBtu / yr \div 2{,}000 lb / ton = 7{,}303 \text{ tpy}$$

Cost Effectiveness

The capital costs were annualized over a 20-year period and then added to the annual operating costs to obtain the total annualized costs for each technology. The cost effectiveness for a combustion controls system (represented by LNB with OFA) and SCR were determined by dividing the total annualized cost by the annual tons reduced. The control technology costs are summarized for Unit 2 in Table 5-5.

In the BART guidelines, EPA calculated that for all types of boilers other than cyclone boilers, combustion control technology is generally more cost-effective than post-combustion controls. EPA estimates that approximately 75 percent of the BART units (non-cyclone) could meet the presumptive $NO_X$ limits at a cost of $100 to $1,000 per ton of $NO_X$ removed based on the use of combustion control technology. For the units that could not meet the presumptive limits using combustion control technology, EPA estimates that almost all of these sources could meet the presumptive limits using advanced combustion controls; the EPA estimates that the cost of such controls are usually less than $1,500 per ton removed.

Table 5-5 indicates that the cost effectiveness of a combustion controls system (represented by LNB with OFA) for La Cygne Unit 2 is less than $1,500 per ton of $NO_X$ removed; however, the cost for SCR is over $1500 per ton of $NO_X$ removed, which is greater than EPA's cost estimate for advanced combustion controls.

### TABLE 5-5. $NO_X$ CONTROL TECHNOLOGY COST SUMMARY (IN 2005 DOLLARS) FOR LA CYGNE UNIT 2

| | Current Annual Emission Rate | Estimated Controlled Emission Rate | | Annual Emissions Reduced | Capital Cost | Annualized Fixed O&M | Annualized Variable O&M | Total Annualized Cost* | Cost Effectiveness |
|---|---|---|---|---|---|---|---|---|---|
| | (tpy) | (lb/MMBtu) | (tpy) | (ton/yr) | ($) | ($/yr) | ($/yr) | ($/yr) | ($/ton) |
| Combustion Controls System** | 10,669 | 0.23 | 7,303 | 3,365 | 20,714,670 | 317,988 | 557,116 | 3,308,249 | 983 |
| SCR | 10,669 | 0.10 | 3,175 | 7,493 | 63,325,110 | 5,560,254 | 1,910,111 | 14,908,532 | 1,990 |

*The costs are annualized in 2005 dollars.

** For the purposes of this analysis, the cost of a combustion control system is represented by a LNB w/OFA system capable of achieving a $NO_X$ emission rate of 0.23 lb/MMBtu.

### 5.4.2 ENERGY IMPACTS & NON-AIR IMPACTS

SCR systems require electricity to operate the blowers and pumps needed to operate the systems. The generation of the electricity will most likely involve fuel combustion, which will cause emissions. While the required electricity will result in the emissions, the emissions should be small compared to the reduction in $NO_x$ that would be gained by operating an SCR system

SCR can potentially cause significant environmental impacts related to the usage and storage of ammonia. Storage of aqueous ammonia above 10,000 lbs is regulated by a risk management program (RMP), since the accidental release of ammonia has the potential to cause serious injury and death to persons in the vicinity of the release. Ammonia can also be emitted in the exhaust of boilers that operate with SCR or SNCR for $NO_X$ control due to ammonia slip.

Ammonia slip from SCR and SNCR systems occurs either from ammonia injection at temperatures too low for effective reaction with $NO_x$, leading to an excess of unreacted ammonia, or from over-injection of reagent leading to uneven distribution; which also leads to an excess of unreacted ammonia. Ammonia released from SCR and SNCR systems will react with sulfates and nitrates in the atmosphere to form ammonium sulfate. Together, ammonium sulfate and ammonium nitrate are the predominant sources of regional haze.

### 5.4.3 REMAINING USEFUL LIFE

The remaining useful life of Unit 1 and Unit 2 do not impact the annualized capital costs of potential controls because the useful lives of the units are anticipated to be at least as long as the capital cost recovery period, which is 20 years.

## 5.5 EVALUATION OF FEASIBLE $NO_X$ CONTROLS IMPACT ON VISIBILITY

The final impact analysis was conducted to assess the visibility improvement for existing emission rates when compared to the presumptive BART emission rates. The existing and presumptive BART emission levels were modeled using CALPUFF. The existing emission rates are the same rates that were modeled for the BART applicability analysis. The BART rates are the presumptive limits (in lb/MMBtu) multiplied by the historical maximum daily heat inputs. The existing and BART emission rates are summarized in Table 5-6.

**TABLE 5-6. EXISTING AND PRESUMPTIVE BART EMISSION RATES**

| | **Existing Emission Rate** | | | **Presumptive BART Emission Rate** | | |
|---|---|---|---|---|---|---|
| | $SO_2$ (lb/hr) | $NO_X$ (lb/hr) | $PM_{10}$ (lb/hr) | $SO_2$ (lb/hr) | $NO_X$ (lb/hr) | $PM_{10}$ (lb/hr) |
| La Cygne - Unit 1 | 6,151.15 | 11,589.52 | 53.79 | 1,396.80 | 931.20 | 53.79 |
| La Cygne - Unit 2 | 8,316.15 | 3,543.47 | 94.92 | 1,243.19 | 1,906.23 | 94.92 |

The visibility improvement due to the presumptive BART limits was calculated as the difference between the existing visibility impairment and the visibility impairment for the presumptive rates. A comparison of the existing visibility impacts and the visibility impacts based on the presumptive BART emission rates, including the maximum modeled visibility impact, 98th percentile modeled visibility impact, and the modeled number of days with a modeled visibility impact greater than 0.5 Δdv, for each Class I area is provided in Table 5-7. It should be noted that the visibility impacts presented in Table 5-7 are based on the application of the presumptive BART limits for both $SO_2$ and $NO_x$. The analysis included the presumptive BART limits from both $SO_2$ and $NO_X$ in order to determine the overall visibility improvement that would be gained from applying BART to both pollutants. The presumptive BART limits for $SO_2$ are discussed in Section 4.

**TABLE 5-7. MODELED IMPACTS BASED ON EXISTING AND PRESUMPTIVE BART EMISSION RATES**

| | **Caney Creek Wilderness** | | | **Hercules Glades Wilderness** | | | **Mingo Wilderness** | | | **Upper Buffalo Wilderness** | | | **Wichita Mountains Wilderness** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement | Existing | BART | Improvement |
| Max Impact (Δdv) | 5.16 | 1.28 | 75% | 4.48 | 1.00 | 78% | 3.82 | 0.87 | 77% | 6.36 | 1.56 | 75% | 8.40 | 2.12 | 75% |
| 98% Impact (Δdv) | 1.14 | 0.23 | 80% | 1.74 | 0.36 | 79% | 0.92 | 0.18 | 81% | 1.92 | 0.42 | 78% | 1.02 | 0.21 | 80% |
| Days > 0.5 | 63 | 5 | 92% | 138 | 6 | 96% | 62 | 3 | 95% | 125 | 14 | 89% | 57 | 7 | 88% |

As seen in Table 5-6, the visibility impacts (the maximum visibility impact, 98th percentile visibility impact, and the number of days with a visibility impact greater than 0.5 Δdv) for each Class I area are lower for the presumptive BART emission rates than for the existing emission rates.

## 5.6 PROPOSED BART FOR $NO_X$

KCP&L has determined that the $NO_X$ BART emission rates are the presumptive emission rates of 0.10 lb/MMBtu and 0.23 lb/MMBtu for Unit 1 and Unit 2, respectively. The presumptive $NO_X$ limit of 0.10 lb/MMBtu for cyclone units is based on the use of SCR and the $NO_X$ limit of 0.23 lb/MMBtu is based on combustion controls. Therefore, KCP&L proposes that the currently permitted SCR is equivalent to BART controls for Unit 1 and that combustion controls, such as LNB or LNB and OFA, or post-combustion controls, such as an SCR, are equivalent to BART controls for Unit 2.

Although KCP&L proposes that combustion controls are equivalent to BART for Unit 2, KCP&L proposes to install an SCR for Unit 2 and further study the installation of combustion controls on Unit 2. KCP&L will further study combustion control options at a later date pending several factors, including other regulatory requirements, availability, and market conditions. The concerns surrounding these factors are described below.

La Cygne Generating Station is located just south of the Kansas City metropolitan area. Based on ozone monitoring data for the past several ozone seasons, KCP&L anticipates that the Kansas City metropolitan area may soon implement regulatory requirements to reduce volatile organic compound (VOC) and $NO_X$ emissions in the area in order to avoid designation as a nonattainment area for the ozone National Ambient Air Quality Standard (NAAQS). Controls at La Cygne Generating Station have already been proposed as part of the Kansas City Ozone Maintenance Plan, which has been submitted and approved by EPA. This may require KCP&L to install $NO_X$ controls sooner than the BART deadline for controls implementation. The extent of $NO_X$ reductions and the exact timeline for implementation that would be required are unknown at this time. KCP&L would like to retain the flexibility to choose a control option based on upcoming ozone standard regulatory requirements that may require additional $NO_X$ controls prior to the BART deadline.

Lastly, market conditions and vendor availability at the time of the BART implementation may drive the selection of combustion control options. At that time, a more detailed study analysis may determine that one combustion control is more favorable than the other.

Additional details on the proposed compliance demonstration methods are provided in Section 7.

# 6. PM BART EVALUATION

The primary source of PM from Unit 1 and Unit 2 is the fly ash in the flue gas. Other sources of PM include unburned carbon present in the flue gas, which is the result of incomplete combustion, and reactions of $SO_2$ and $NO_X$ compounds to form fine PM in the form of nitrates, sulfur trioxide, sulfates, and sulfuric acid mist.

The maximum daily $PM_{10}$ emission rates that were modeled for the BART applicability determination are summarized in Table 6-1.

**TABLE 6-1. HISTORICAL MAXIMUM 24-HOUR $PM_{10}$ EMISSION RATE**

| | Maximum 24-Hour Heat Input (MMBtu/24hr) | $PM_{10}$ Emission Rate (lb/hr) | $PM_{10}$ Emission Rate (lb/MMBtu) |
|---|---|---|---|
| La Cygne - Unit 1 | 223,488 | 53.79 | 0.006 |
| La Cygne - Unit 2 | 198,911 | 94.92 | 0.011 |

From Table 6-1 it can be seen that the current $PM_{10}$ emission rates for Unit 1 and Unit 2 are much less than the current emission rates of $SO_2$ and $NO_X$. The low $PM_{10}$ emission rates correspond to very low visibility impacts attributable to $PM_{10}$ when compared to the impacts attributable to $SO_2$ and $NO_X$, as shown in Table 6-2.

**TABLE 6-2. VISIBILITY IMPAIRMENT CONTRIBUTIONS**

| Year | Visibility Impairment Attributable to $SO_4$[1] (%) | Visibility Impairment Attributable to $NO_3$[2] (%) | Visibility Impairment Attributable to $PM_{10}$[2] (%) |
|---|---|---|---|
| Wichita Mountains | 82.89 | 17.02 | 0.10 |
| Hercules Glades | 19.63 | 79.99 | 0.38 |
| Caney Creek | 24.32 | 75.46 | 0.22 |
| Upper Buffalo | 20.20 | 79.53 | 0.27 |
| Mingo Wildlife | 42.26 | 57.61 | 0.11 |

1 The visibility impairment attributable to $SO_4$ is primarily from $SO_2$ emissions. A very small portion is from $SO_4$ emitted as condensable particulate.

2 The visibility impairment attributable to $NO_3$ is entirely from $NO_X$ emissions.

3 The visibility impairment attributable to $PM_{10}$ is the sum of the visibility impairment attributable to all modeled primary PM species (PMc, PMf, EC, and SOA).

Given the small $PM_{10}$ emission rates compared to $SO_2$ and $NO_X$ and the small contribution of $PM_{10}$ to the visibility impacts, any additional control technology would provide little visibility improvement and require significant capital expenditures. Therefore, additional control technologies would not be cost effective, and are not required as PM control technologies for BART compliance. Although not required for BART compliance, KCP&L plans to install a baghouse on Unit 1 and Unit 2 for compliance with other environmental regulations.

# 7. PROPOSED BART LIMITS COMPLIANCE SUMMARY

## 7.1 $SO_2$ BART COMPLIANCE SUMMARY

Based on the $SO_2$ BART analysis, KCP&L has determined that the BART limit for $SO_2$ for Unit 1 and Unit 2 is the presumptive emission limit of 0.15 lb/MMBtu. Per the BART guidelines, states may allow sources to "average" emissions across any set of BART-eligible emission units within a fenceline, so long as the emission reductions from each pollutant being controlled for BART would be equal to those reductions that would be obtained by simply controlling each of the BART-eligible units that constitute a BART-eligible source. The weighted average of the BART limits for Unit 1 and Unit 2 is 0.15 lbs/MMBtu.

Even though the weighted average of the presumptive BART limits for Unit 1 and Unit 2 is 0.15 lb/MMBtu, KCP&L proposes to demonstrate compliance with a limit that is more stringent than this limit. Specifically, KCP&L proposes a weighted average limit of 0.10 lb/MMBtu on a 30-day rolling average for Unit 1 and Unit 2. The proposed weighted average emission limit is below the presumptive BART emission rates which will result in reductions of the visibility impacts attributable to La Cygne Unit 1 and Unit 2 in excess of those indicated in Sections 4 and 5.

KCP&L proposes to demonstrate compliance with the Unit 1 and Unit 2 weighted average emission limit of 0.10 lbs/MMBtu using the existing CEMS with a new 30-day rolling average report. The CEMS software will be configured to generate a two unit weighted average. The daily average $SO_2$ rate for each unit will be the average of the hourly $SO_2$ rates for each hour of a particular boiler operating day, excluding periods of start-up and shut-down. A boiler operating day will be any day that the unit combusts fuel for any period of time, excluding periods of start-up and shut-down. The two-unit daily average will be calculated using the following equation:

$$\frac{((SO_{2Day\#1} \times HI_{sum\text{-}day\#1}) + (SO_{2Day\#2} \times HI_{sum\text{-}day\#2}))}{(HI_{sum\text{-}day\#1} + HI_{sum\text{-}day\#2})}$$

Where:
$SO_{2day\#1}$ = Daily average of hourly $SO_2$ rates for Unit 1
$SO_{2\ day\#2}$ = Daily average of hourly $SO_2$ rates for Unit 2
$HI_{sum\text{-}day\#1}$ = Summation of hourly heat inputs for the day for Unit 1
$HI_{sum\text{-}day\#2}$ = Summation of hourly heat inputs for the day for Unit 2

The 30-day rolling average will be the simple average of the last 30 days of two-unit daily averages and will be in compliance if it is less than 0.10 lbs/MMBtu, excluding periods of start-up and shut-down.

Periods of start-up and shut-down for Unit 1 and Unit 2 will be based on good industry practice or the manufacturer's recommendations.

## 7.2 $NO_X$ BART COMPLIANCE SUMMARY

Based on the $NO_X$ BART analysis, KCP&L has determined that the BART limits for $NO_X$ are the presumptive emission limits of 0.10 lb/MMBtu and 0.23 lb/MMBtu for Unit 1 and Unit 2, respectively. Per the BART guidelines, states may allow sources to "average" emissions across any set of BART-eligible emission units within a fenceline, so long as the emission reductions from each pollutant being controlled for BART would be equal to those reductions that would be obtained by simply controlling each of the BART-eligible units that constitute a BART-eligible source. The weighted average of the presumptive BART limits for Unit 1 and Unit 2 is 0.16 lbs/MMBtu. The Unit 1 + Unit 2 weighted average emission limit has been calculated as follows:

$$\frac{\sum_{i=1}^{2} R_{ip} \times HI_{im}}{\sum_{i}^{2} HI_{im}}$$

Where
$R_{ip}$ = Presumptive BART emission rate for unit i (lb/MMBtu)
$HI_{im}$ = Maximum daily heat input from 2002-2004 (MMBtu/day) for unit i

The detailed calculation of the weighted presumptive emission limit is shown below.

$$\frac{\left(R_{1p} \times HI_{1m}\right) + \left(R_{2p} \times HI_{2m}\right)}{\left(HI_{1m} + HI_{2m}\right)} = 0.16 \text{ lb/MMBtu}$$

Where:
$R_{1p}$ = Presumptive BART emission rate for Unit 1 (lb/MMBtu) = 0.10 lb/MMBtu
$HI_{1m}$ = Maximum daily heat input from 2002-2004 (MMBtu/day) for Unit 1 = 223,488 MMBtu/day
$R_{2p}$ = Presumptive BART emission rate for Unit 2 (lb/MMBtu) = 0.23 lb/MMBtu
$HI_{2m}$ = Maximum daily heat input from 2002-2004 (MMBtu/day) for Unit 2 = 198,911 MMBtu/day

Even though the weighted average of the presumptive BART limits for Unit 1 and Unit 2 is 0.16 lb/MMBtu, KCP&L proposes to demonstrate compliance with a limit that is more stringent than this limit. Specifically, KCP&L proposes a weighted average limit of 0.13 lb/MMBtu on a 30-day rolling average for Unit 1 and Unit 2. The proposed weighted average emission limit is below the presumptive BART emission rates which will result in reductions of the visibility impacts attributable to La Cygne Unit 1 and Unit 2 in excess of those indicated in Sections 4 and 5.

KCP&L proposes to demonstrate compliance with the Unit 1 and Unit 2 weighted average emission limit of 0.13 lbs/MMBtu using the existing CEMS with a new 30-day rolling average report. The CEMS software will be configured to generate a two unit weighted average. The daily average $NO_X$ rate for each unit will be the average of the hourly $NO_X$ rates for each hour of a particular boiler operating day, excluding periods of start-up and shut-down. A boiler operating day will be any day that the unit combusts fuel for any period of time, excluding periods of start-up and shut-down. The two-unit daily average will be calculated using the following equation:

$$\frac{((NO_{X\,Day\#1} \times HI_{sum\text{-}day\#1}) + (NO_{X\,Day\#2} \times HI_{sum\text{-}day\#2}))}{(HI_{sum\text{-}day\#1} + HI_{sum\text{-}day\#2})}$$

Where:
$NO_{X\,day\#1}$ = Daily average of hourly $NO_X$ rates for Unit 1
$NO_{X\,day\#2}$ = Daily average of hourly $NO_X$ rates for Unit 2
$HI_{sum\text{-}day\#1}$ = Summation of hourly heat inputs for the day for Unit 1
$HI_{sum\text{-}day\#2}$ = Summation of hourly heat inputs for the day for Unit 2

The 30-day rolling average will be the simple average of the last 30 days of two-unit daily averages and will be in compliance if it is less than 0.13 lbs/MMBtu, excluding periods of start-up and shut-down.

In the event of an extraordinary situation involving an extended outage of Unit 2 (duration in excess of 10 weeks) KCP&L will submit a plan to KDHE to achieve compliance with a La Cygne Unit 1 $NO_X$ presumptive limit of 0.10 lbs/MMBtu on a 30-day rolling average excluding periods of start-up and shut-down. The 10-week period is intended to cover all anticipated scheduled outages so that this scenario would only come up in the case of a unit retirement or a catastrophic loss of one unit.

Periods of start-up and shut-down for Unit 1 and Unit 2 will be based on good industry practice or the manufacturer's recommendations.

## 7.3 $PM_{10}$ BART COMPLIANCE SUMMARY

KCP&L proposes that no additional PM controls are required for BART compliance. Although not required for BART compliance, KCP&L plans to install a baghouse on Unit 1 and Unit 2 for compliance with other environmental regulations.

KCP&L proposes to demonstrate compliance with the La Cygne Unit 1 and Unit 2 average emission limit of 0.015 lbs/MMBtu for $PM_{10}$ (filterable) and 0.024 lbs/MMBtu for $PM_{10}$ (total) by conducting annual stack tests. Compliance is demonstrated if the weighted average stack test results of the two units combined meets the emission limits. Annual stack test results will be the average of three one-hour stack tests for each unit.